Towards Biodiversity Credits

– A qualitative case study in Yayasan Sabah Forest Management Area, Borneo Malaysia

Mot krediter för biologisk mångfald - En kvalitativ fallstudie i Yayasan Sabah Forest Management Area, Borneo Malaysia

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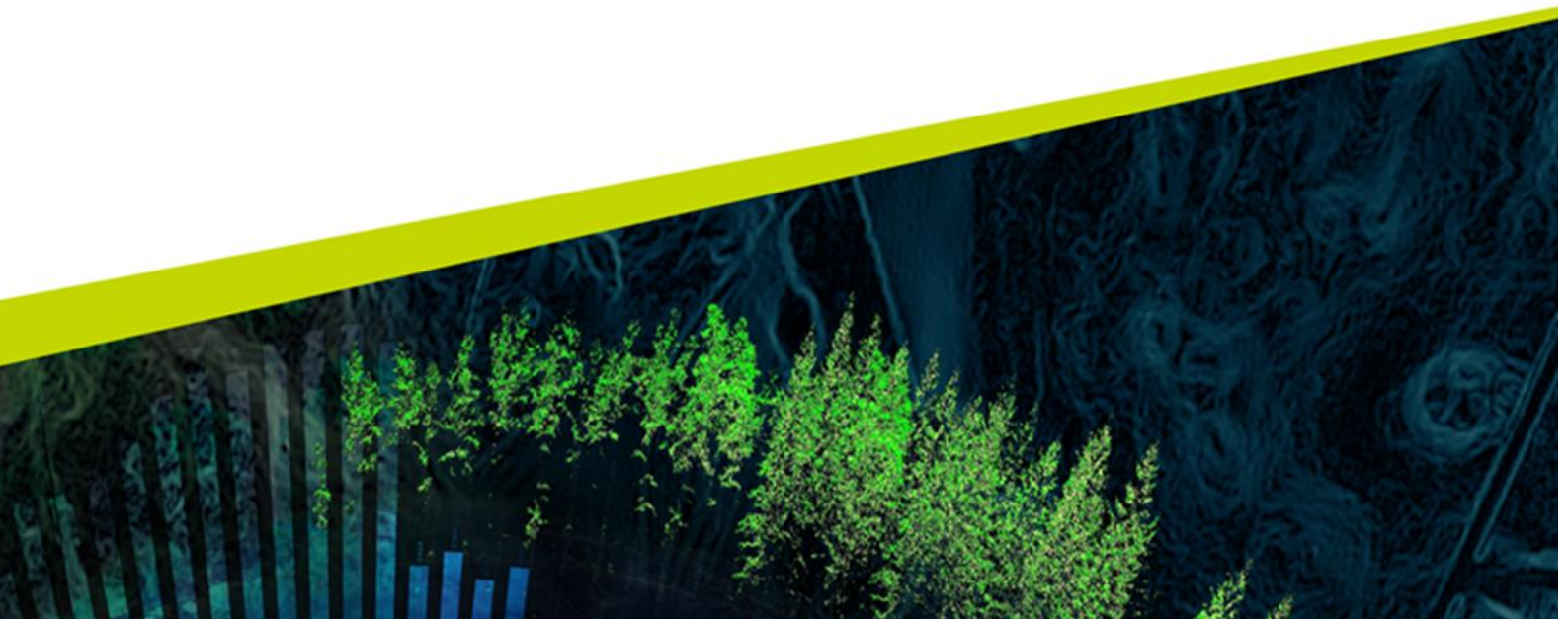

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Summary

Most people are aware of the ongoing climate crisis and its consequences for all life on Earth. As temperatures rise, global ecosystems are affected and the vital services they provide. Global biodiversity is declining as a result of human activity. One reason why biodiversity and biological values are under-prioritised in relation to other natural resources, and despite their important function, is that they are difficult to value in economic terms. There are those who argue that biodiversity is invaluable, which is not wrong, but in order for biodiversity values to be prioritised at a higher level among decision-makers, an economic system can be considered necessary.

The aim of this study was therefore to investigate the concept of biodiversity credit and its function as an economic system to promote biodiversity. The study aimed to investigate the economic, biological and social conditions for the concept of biodiversity credits in rainforest environments. The study was carried out as a case study where the conditions for biodiversity credit were investigated within the framework of the governmental organisation Yayasan Sabah Forest Group in Borneo, Malaysia. The organisation already has an ongoing mission to reforest and promote biodiversity within the management area through research-funded projects, so part of the aim was to investigate how these efforts could be applied in a biodiversity credit system.

The case study followed a qualitative, flexible and abductive design and consisted of data collection in four parts. Two different types of species data were collected: tree data and audio recording data capturing animal sounds. The species data were collected in different land areas to specifically distinguish how biodiversity was characterised in the areas where active reforestation measures were carried out. The other two data collections consisted of thematic data in the form of an observational study consisting of field notes and an interview study with two staff members within the organisation aimed specifically to investigate organisational and social aspects. The results were then applied to a hypothetical credit system as part of the analysis to investigate whether the organisation's conditions are applicable according to the conditions to be met for certification in a credit system.

The results and analysis indicated that the prospects for the organisation to connect to a biodiversity credit system look promising, but that some factors need further investigation. Among other things, further investigation is needed into the economic conditions and expanded measurements of how biodiversity differs in the various land areas. There are several reasons why joining a biodiversity credit system could benefit the organisation, including the need for broader funding and the fact that the organisation's role in the local community, which is initially good, could be further strengthened. In addition, the measurements, although as mentioned above they would need to be expanded, show that the active actions that have been and are being carried out are important for biodiversity.

In conclusion, this study concludes that there is potential for the organisation to join a biodiversity credit system and that such a system is expected to promote biodiversity.

Key words: *biodiversity, credit, organisation, Plan Vivo Foundation, species*

Sammanfattning

De allra flesta är medvetna om den pågående klimatkrisen och dess konsekvenser för allt levande på jorden. Med en stigande temperatur påverkas de globala ekosystemen och de livsviktiga tjänster de tillhandahåller. Den globala biodiversiteten minskar och detta till följd av mänsklig aktivitet. En anledning till att biodiversitet och biologiska värden underprioriteras i förhållande till andra naturresurser och trots dess viktiga funktion, är att det är svårt att värdera ur ekonomiska termer. Det finns röster som argumenterar för att biologisk mångfald är ovärderligt, vilket inte är fel, men för att biologiska värden ska prioriteras på högre instans bland beslutsfattare kan ett ekonomiskt system anses vara nödvändigt.

Målsättningen med denna studie var därmed att undersöka konceptet biodiversitetskrediter och dess funktion i syfte att som ekonomiskt system främja biologisk mångfald. Studien syftade till att undersöka de ekonomiska, biologiska och sociala förutsättningarna för konceptet biodiversitetskrediter i regnskogsmiljö. Studien utfördes som en fallstudie där förutsättningarna för biodiversitetskrediter undersöktes inom ramarna för den statliga organisation Yayasan Sabah Forest Group på Borneo, Malaysia. Organisationen har redan ett pågående uppdrag att genom forskningsfinansierade projekt återbeskoga och främja biologisk mångfald inom förvaltningsområdet. En del av syftet låg därför i att undersöka hur dessa insatser kunde appliceras i ett system för biodiversitetskrediter.

Fallstudien utformades enligt en kvalitativ, flexibel och abduktiv design och bestod av datainsamling i fyra delar. Två olika typer av artdata insamlades: träddata och ljudinspelningsdata som fångade djurläten. Artdatan insamlades i olika landområden för att särskilt kunna urskilja hur biodiversiteten utmärkte sig i de områden där aktiva åtgärder för återbeskogning utförts. De andra två datainsamlingarna bestod av tematiska data i form av en observationsstudie bestående av fältanteckningar samt en intervjustudie med två medarbetare inom organisationen som syftade särskilt till att undersöka organisatoriska och sociala aspekter. Resultatet applicerades sedan i ett hypotetiskt kreditsystem som en del av analysen för att undersöka om organisationens förutsättningar är tillämpliga enligt de villkor som ska uppfyllas för certifiering i ett kreditsystem.

Resultat och analys pekade på att utsikterna för organisationen att ansluta sig till ett system för biodiversitetskrediter ser goda ut, men att vissa faktorer behöver utredas ytterligare. Bland annat behövs vidare utredning för de ekonomiska förutsättningarna samt utvidgade mätningar i hur biodiversiteten skiljer sig åt i de olika landområdena. Det finns flera olika anledningar som talar för hur en anslutning till ett system för biodiversitetskrediter skulle kunna gynna organisationen, bland annat är de i behov av en breddad finansiering och organisationens betydelse för lokalsamhället, som initialt är bra, skulle kunna stärkas ytterligare. Dessutom visar mätningarna, trots att de som sagt skulle behöva utvidgas, att de aktiva åtgärder som har utförts och utförs är betydelsefulla för den biologiska mångfalden.

Avslutningsvis är slutsatsen för denna studie att det finns förutsättningar för organisationen att ansluta sig till ett system för biodiversitetskrediter och att ett sådant system väntas främja den biologiska mångfalden.

Nyckelord: *arter, biologisk mångfald, kredit, organisation, Plan Vivo Foundation*

Preface

I would like to start by thanking the local support in Luasong for the warm welcome and organisation of our field studies – a special thanks to research assistant Albert Lojingi, Ardin Lagundi, Dizolkeply Sundolon and Musa Marjani who made the study possible. Also, a big thanks to senior officer Pius Pansang who planned it all. I would also like to express my gratitude Mr Sukar Burhan, who allowed us to charge our equipment in his restaurant when a power cut lasting several days made administrative work difficult - This shows the kind-hearted and helpful local community in Luasong.

Furthermore, I would like to express my heartfelt thanks to Agnes Mørch Nielsen and Johan Närvä for good co-operation in the field and pleasant company during our joint adventure in Borneo.

Last but not least, I would like to thank my supervisors, Anders Roos and Petter Axelsson, who have supported me with their respective areas of expertise.

The experiences in Luasong and Borneo have been a journey both physically and mentally, and I have not only brought home data but also memories for life. I am forever grateful to all parties who made this journey possible for me.

THANKS

Clara Hernblom
Uppsala, June 2024

From left: Johan Närvä (Umeå University), Agnes Mørch Nielsen (University of Copenhagen), Albert Lojingi (research assistant), Clara Hernblom (Swedish University of Agricultural Sciences) and Petter Axelsson (Swedish University of Agricultural Sciences).

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PV	Plan Vivo	Page 23
SLU	Swedish University of Agricultural Science	Page 17

1 Introduction

The introduction chapter of this thesis introduces with a background to the thesis, the problem that intends to be examined and the aim of the study together with research questions.

1.1 Background

The ongoing climate degradation is real and is describes as a decisive threat to all of humanity (The Global Goals n.d.a). The climate crisis is particularly explained by the emission of greenhouse gases leading to global warming, which affects the risk of natural disasters, food production, and ecosystems providing essential services. To limit the effects of global warming, the UNFCCC and the Paris Agreement (UNFCCC 2024) clarify as part of the global goals that the temperature increase must be limited to below two degrees with a long-term goal of 1.5 degrees (The Global Goals n.d.a).

The climate crisis is clearly interconnected with biodiversity. Global warming affects biodiversity as the rise in temperature contributes to an increase in the intensity and frequency of extreme weather events, impacting many aspects of biodiversity (IPBES 2019). Many types of ecosystems are affected, from marine environments to savannas and rainforests, which in turn affect provisioning services such as agriculture and fisheries, and therefore humans *(ibid.).*

Biodiversity is crucial for all life on Earth (The Global Goals n.d.b). From a human needs perspective, biodiversity and ecosystems are essential for survival. Humans need functioning ecosystems and ecosystem services to meet their needs for water, food, energy, and materials. Biodiversity is described as vital for all life on Earth, and global ecosystems provide habitats for animals and plants while supplying the world with oxygen through photosynthesis and cellular respiration *(ibid.).*

Despite the vital importance of biological values, global biodiversity is decreasing (WWF 2022). The rate is accelerating with climate change, as confirmed by figures presented by the World Wildlife Fund (WWF) through the Living Planet Index (LPI) *(ibid.).*

1.2 Problem

A large proportion of global biodiversity is found in the world's forests, and the forest play a central role in the green transition by acting as carbon sinks, providing renewable products and creating habitats for animals and plants through favourable conditions for biodiversity (FAO 2020b). Yet, biodiversity is not valued as highly as other values in the forest. Some of the explanation lies in the difficulty to value biodiversity in purely economic terms (Boillat & Ifejika Speranza 2019). There are several mathematical and economic models for carbon storage as well as for wood as a raw material and product (TEEB 2011). Biodiversity, on the other hand, is both difficult to value and to put an economic price on. This gives that biodiversity is not valued by decision-makers. The economic interpretation of the constantly declining level of biodiversity argues that the economic contribution of biodiversity is often downgraded by those in power, especially because the benefits are difficult to evaluate in economic terms. At the same time, many describe biodiversity as invaluable, but an economic

model and a valuation of all the benefits of the forest, not least biodiversity, are necessary for society to make well-founded decisions on land-use-related issues *(ibid.).*

An economic system that values biodiversity could be the solution to ensuring that biodiversity is valued as highly as other resources, thereby promoting it and counteracting biodiversity loss, which in turn would benefit the climate (UNEP 2023). There are ways to slow and even reverse the trend of global biodiversity loss, which include increasing conservation efforts and restoring ecosystems (Biodiversity Credits 2022). But it will require significant work and to reverse the current negative trend.

1.3 Aim and research questions

The aim of this study was to explain the biological, economic and social conditions for the concept of biodiversity credits in tropical rainforest environments. In order to study the concept, a case study will be conducted with the aim of examining the theoretical conditions in the governmental organisation Yayasan Sabah Forest Management Area, Luasong, Sabah Borneo.

The organisation has an existing mission for forest restoration and rehabilitation and operates research-funded projects in the field of reforestation. The study will explore whether the efforts already made and being made can be included in the concept of biodiversity credits. The study will consist of data collection in four parts: Collection of tree data and species data through audio recording, aiming to investigate how the degree of biodiversity differs in the areas where active biodiversity promotion efforts have been carried out and whether it is measurable. The second part consists of a thematic analysis that includes an observational and interview study and aims to investigate the social and organisational conditions for biodiversity credits. To study whether the results of the data collection can be applied to the concept of biodiversity credits, a hypothetical credit system and its requirements for certification will be examined.

The purpose will be answered by investigating the following research questions:

-*What economic, biological and social conditions are required to establish the concept of biodiversity credits in the organisation?*
- *Is the organisation's structure and ongoing reforestation efforts applicable in the context of biodiversity credits?*
-*Is the concept of biodiversity credits an appropriate way to improve biodiversity in the rainforest environment?*

1.4 Delimitations

The theory was delimited by boiling it down to focus specifically on how economic systems for biodiversity work in practice, which sets the framework for the whole study. The study is delimited in its entirety by being designed as a case study in which an organisation and its associated conditions are examined to investigate the concept of biodiversity credits. This means that the methodology and research design were delimited according to the geography that constitutes the location of the unit of analysis, and is limited to the structure and context of the organisation. For further delimitation in the methodology and also analysis, a

hypothetical credit system was studied to simulate as authentic conditions as possible to investigate the research questions of the case study.

Furthermore, the case study was carried out from the perspective of an organisation already initially working on restoration as part of its mission, which set the framework for results and analysis when comparing results and examining the organisation's existing conditions and infrastructure.

1.5 Thesis structure

The thesis consists of nine chapters in total (Figure 1).

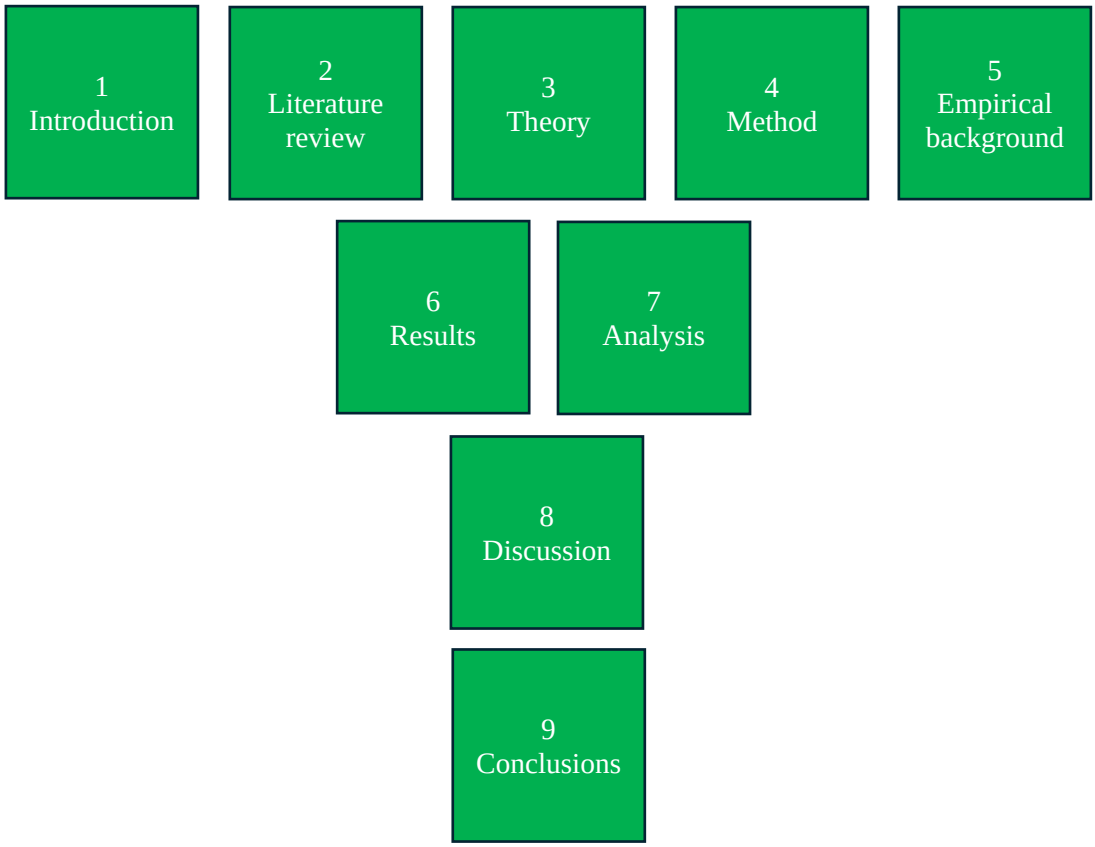

Figure 1. Illustration of the thesis structure.

This study initially consists of an introductory chapter that breaks down the study's purpose and associated research questions (Chapter 1). This is followed by the literature review for the study (chapter 2), followed by the theoretical frameworks that underlie the study (Chapter 3). The next section presents the study's method and research design, including a description of data collection and analysis (Chapter 4). This is followed by the empirical background, which complements the previous sections with factual information (Chapter 5). The next chapter presents the results of the study (Chapter 6) followed by an analysis of the results (Chapter 7). Finally, a discussion of the research results follows (Chapter 8), leading to the conclusion of the study (Chapter 9).

2 Literature review

Following chapter consist of a literature review that aims to gain a deeper understanding of the topic of this study.

2.1 The global biodiversity

Biodiversity means biological diversity and is defined as the total sum of all biological variation, from the ecosystem level down to the gene level (Purvis & Hector 2000). The definition is explained as a simple yet broad description of the concept. The authors of the article describe how biodiversity cannot be fully reflected by a metric or a number, and that it is challenging to measure such a broad concept as biodiversity that should also be useful *(ibid.).*

Li and Wiens (2023) argues that the current estimation of biodiversity from a global perspective can be considered a total failure. Recent and well-cited reports and metrics indicate that the extent of global species richness is not entirely clear. In one well known and cited study, global species richness is estimated at around 11 million species (Mora et al. 2011). Another study suggests around 2 million species (Costello et al. 2012) and another one suggests a trillion or even more species (Locey & Lennon 2016). Li and Wiens (2023) further describes how part of the different estimates lies in the extent to which microbial and macroscopic species are included. The microbial species are many more numerous, which means that the macroscopic species are less significant in comparison *(ibid.).* Microbial species, or microorganisms as they are also called, are as the name suggests microscopically small organisms that cannot be observed with the human eye, such as bacteria (Genetiknämnden 2020). In contrast, macroscopic species are species that can be observed, such as earthworms (SLU 2024).

Li and Wiens (2023) also discusses how non-described species are accounted for in different estimates. Some estimates suggest that each insect, which itself accounts for about half of the described species, hosts at least one unique microorganism (such as fungus or mite). The authors of the report estimate, through a systematic study of the global morphologically based species and cryptic species (meaning species are equated based on external characteristics rather than evolutionary), that biodiversity can be estimated to correspond to a range between 563 million and 2.2 billion species *(ibid.).* The official, currently estimated number of described species corresponds to 2.01 million species (Bánki 2022).

2.2 Biodiversity and the forest

Forests and biodiversity are very strongly linked. Global forests are home to the majority of the world's species and thus play an essential role in global species diversity (Pan et al. 2018). Forest biodiversity provides many of the vital ecosystem services for all life on earth and individual species have an important functionality in the structure of the ecosystem and therefore ecosystem services *(ibid.).*

For biodiversity conservation, the world's forests play a very important role (Hill et al. 2019). While humanity is dependent on the biodiversity of the world's forests, it is humans and their increasing demand for forest resources and land that has led to massive deforestation and ecosystem loss globally. This includes the demand for forestry materials such as timber and

the demand for land for agriculture. Deforestation mainly affects those species that depend on unspoilt forests *(ibid.).*

In order to study how forest biodiversity is affected by human activity, data on forest landscape change and forest status produced by remote sensing (aerial imagery) have been essential (Hill et al. 2019). The article describes a scientific mapping of the world's forests and their importance for biodiversity using remote sensing. The results show first of all that the role of forests for biodiversity and their importance for species diversity varies globally. For example, there are species-rich areas with low geographical distribution in Southeast Asia, while there are species-rich areas with high geographical distribution in the Amazon, followed by low species richness with high geographical distribution in large parts of the temperate region *(ibid.).*

The results of the mapping also show how biodiversity has been affected by deforestation during the period 2000-2018, which refers to deforestation resulting from human activity and natural disturbances such as storms or fires (Hill et al. 2019). The mapping shows that a change from over 60% to 0% of tree cover in an area of 1 km2 results in a disproportionate loss of biodiversity from a global perspective. The areas with the greatest losses in terms of species richness and due to loss of forest cover include Southeast Asia, Central America and West Africa *(ibid.).*

2.3 Nature credit market

Global natural resources are the foundation of the world's economy (Nature Markets 2022). It is widely known that the use of the planet's natural resources is unsustainable due to the impact on global ecosystems. Forces around the world, both in the field of research and in the form of public demonstrations in favour of nature, are shaking up the market. What is now happening in the market for natural resources can be described as a historical transition where natural assets are valued economically in a new way - it is not only the raw material or land that is valued financially, but now also the ecosystems and their services *(ibid.).*

The authors describe how there are both risks and possibilities with this new market, because economics will always be the main driver for both the use and conservation of natural resources, at least at a global level (Nature Markets 2022).The risks with a market for nature credits are that only those factors that generate economic profitability in the short term are prioritized. At the same time, the market opens opportunities for the next generation to use financial instruments to create sustainable business models that in the future can promote natural resources to a greater extent than today *(ibid.).*

The author further describes how the credit market for natural resources is part of an innovation cycle (Nature Markets 2022). Previous policy initiatives have failed to bring economic sustainability to natural resource financing models. However, the concept of nature credits is described as a reliable approach to delivering both the right incentives and financing model necessary for the global finance industry to meet the global targets for promoting biodiversity. For this to be possible, the key objectives of impact, scale and price need to be addressed.

The market for credits in various forms exists globally. One market for natural credits that is particularly distinctive is the carbon credit market, which is described as the most significant of today's nature credits. The market for biodiversity credits is described as less significant

from an economic perspective, but as a market with growing demand and supply *(ibid.)*.

Biodiversity credits can be expected to play a complementary role to the market for voluntary carbon credits and a well-structured natural resource crediting system could thus promote the contribution of private finance in nature conservation (Biodiversity Credit Alliance 2024). Private finance currently accounts for 17% of the total financial funding for nature conservation activities globally and this category thus plays a significant role in the market.

2.4 Biodiversity credits

As the market for natural and ecological credits is starting to take form in the global economy, one financial compensation system for biodiversity is the concept of biodiversity credits, also known as biodiversity credits or conservation credits is being established (Nature Markets 2022). Biodiversity credits are an instrument whereby companies and non-companies invest in a project for the purpose of benefiting biodiversity (Biodiversity Credits 2022). The credit should describe how and where an action has been taken, what methods have been used and who has carried out the action. A credit is designed according to a juridical framework and must be certified according to a specific standard, after which the credit can be declared and then traded *(ibid.)*.

What distinguishes the concept from more general compensation systems is that biodiversity credits are usually not regulated by law and can be described as a more voluntary incentive (Biodiversity Credits 2022). Around the world, it is otherwise common for ecological compensation to be used for biodiversity loss because of exploitation. Then, ecological compensation is often regulated by law and is a requirement for authorization or building permits *(ibid.)*.

There is no universal system, the concept of biodiversity credits differs depending on the type of requirement, meaning whether it is protection, conservation adaptation or creation and restoration of natural values that is considered (Biodiversity Credits 2022). The structure of the system can also differ; here are three ways in which a biodiversity credit can be structured (Squires et al. 2021): 1) The "cap-and-trade method" involves delimiting areas through direct regulation to create untouched ecosystems that can then be used for credits. 2) The "penalty-and-reward method", whereby credits are created by rewarding positive behaviour, in other words the preservation of ecosystems, and penalizing negative behaviour, meaning the use of ecosystems. The reward is typically an indirect subsidy and the punishment an indirect tax. 3) The third method can be described as a hybrid of the other two *(ibid.)*.

2.4.1 Pricing of a biodiversity credit

There is still no established, internationally recognized pricing for biodiversity credits (Gradeckas 2023). The value of a biodiversity credit is determined by the method of crediting chosen and the agreed inputs involved in issuing credits.

The research-based website Bloom Lab which publishes newsletters and offers consultation on biodiversity finance, has a robust database of all established organizations involved in voluntary biodiversity finance globally (Gradeckas 2023), presents a summary of the factors that matter most in the pricing of a biodiversity credit considering the factors of the approximately 450 registered organisations in the nature credit market database (Gradeckas 2024b):

1. Geography and surrounding environment of the project/conservation effort. For example, the environment and local climate can affect the level of biodiversity which in turn can affect the price.
2. The scale of the project/operation. The size and complexity of an intervention also plays a role in the price. This can include resource issues such as staff requirements.
3. Biological environment and ecosystem services. The price is influenced by the biological environment and associated ecosystem services - the more valuable the environment and important ecosystem services are conserved and/or favoured - the higher the price can be expected.
4. Administrative costs. All costs involved in monitoring, administration, certification, verification, and others affect the price.
5. Supply and demand. Market conditions affect the price. This includes the demand from local and global organisations, companies and governments wanting to invest in biodiversity credits, often for the purpose of achieving sustainability and/or climate targets *(ibid.).*

It is difficult to find documented cases of biodiversity credit trading. But, in a known and public affair, the Swedish bank Swedbank bought biodiversity credits through the Swedish research project Biodiversity credits run by the Swedish University of Agricultural Sciences, SLU in Orsa Besparingsskog (Swedbank n.d.). Orsa Besparingsskog is a large, conserved forest area in the Dalarna region of Sweden. Swedbank has purchased a total of 91 credits on an area of 11 hectares in Orsa Besparingskog. The validity period corresponds to 20 years *(ibid.).* This affair does not provide any information about the pricing of a credit, but it does give an indication of the scale of a credit in an area.

2.5 Ethical aspects about credit systems

The ethical aspects are important to consider when discussing economic interests in natural resources. Globally, there are large natural areas and important biodiversity resources that directly impact and/or are owned by local and indigenous people (Biodiversity Credit Alliance 2024). These biodiversity resources are important for the promotion of global biodiversity and effective engagement with local and indigenous peoples is therefore essential.

As the rapidly growing carbon credit market has progressed, some important lessons have been learnt: Clear principles and regulations must be formulated so that those living closest to the resource in question receive fair outcomes (Biodiversity Credit Alliance 2024). To ensure the most equitable process possible, it is therefore fundamental that local and indigenous peoples are included and given the opportunity to make their voices heard in locally based initiatives *(ibid.).*

Another factor linked to the ethical aspects of natural resources is 'greenwashing'. Greenwashing means that a company or organization reports false information on how they support the environment and/or the climate to promote their own activities (United Nations n.d.).

As described above, one of the risks of the credit market system is that only short-term financial benefits are valued, which risks that the long-term work of promoting biological values is not prioritized (Nature Markets 2022). Such a scenario could be described as greenwashing, where actors make money in the short term without taking responsibility for the long-term process.

3 Theory

The theory chapter aims to demonstrate the theoretical framework that forms the basis for the research design. This chapter presents a framework that demonstrates how Payment for Ecosystem Services integrates with the concept of biodiversity.

3.1 Payment for ecosystem services

Financial compensation and financial payment systems for ecosystem services exist in various forms and have been established all over the world in recent years (IPBES 2017). IPBES describes the concept of payment for ecosystem services: **PES** (Payment for ecosystem services) is a market driven tool aimed to finance nature conservation efforts. The system is targeting locally based actors who are in charge of managing natural environments. The system means that ecosystem services, which are usually free of charge, can be used as economic incentives to promote and conserve them *(ibid.).*

It is appreciated that hundreds of different PES systems have been established around the world since the early 1990s (Grima et al. 2016). A PES system involves important natural resources and large investments, so it is reasonable to analyse the system and its performance, according to the authors, who in their article present the results of an analysis of 40 different case studies of PES systems in Latin America. The analysis aims to inform policy makers on how PES systems can be structured to increase their chances of being successful. The analysis is based on several criteria, such as policy framework and type of ecosystem. The results of the analysis indicate that four factors play a particular role in whether a PES system is successful: 1) The scale, both the temporal and spatial scale is important, where local and regional scales with a time frame of 10-30 years seem to be most successful. 2) Ecosystem services being traded, systems that both benefit local livelihoods and conservation of resources are also found to be successful. 3) Stakeholders, systems where most stakeholders are private and systems that do not involve intermediaries between sellers and buyers tend to be favourable. 4) Transaction type, systems that use in-kind contributions to some extent tend to be more successful than systems that only use cash contributions *(ibid.).*

The authors emphasize that these factors do not guarantee a successful PES system (Grima et al. 2016). PES systems aim to achieve a balance between ecosystem conservation and human well-being, which is difficult, and the systems are sometimes heavily criticized for not doing so. PES systems and associated standards and criteria are constantly evolving and early input from past failures is important for future progress *(ibid.).*

Farley and Costanza (2010) describes in their report how ecosystem services are not included in market decisions because they are not valued on the basis of economic judgements, and how this leads in the long term to a degradation of the capacity of ecosystems to provide ecosystem services. The authors argue that one of the main incentives for people and companies to conserve or protect ecosystems is economic. They go on to describe how PES can be an effective way to address the issue of lack of pricing and its consequences. Farley and Costanza (2010) emphasize that in practical terms it needs to be done by:

-Identifying and mapping ecosystem services and their value
-Clarifying the responsibilities that follow the provision of ecosystem services

-Designing a payment system and/or financial incentives and how this varies in relation to ecological values
-Monitor that the system actually favours ecosystems
-Involve stakeholders, landowners, local people, government and business in the implementation of the system *(ibid.).*

3.2 Conceptual framework

The conceptual framework is based on the theory presented in chapter three. The elements of the framework explain how the Payment for Ecosystem Services (PES) phenomenon interacts with the concept of biodiversity. The conceptual framework is showed below (Figure 2) and will be considered in the following sections.

Figure 2. Illustrates the conceptual framework for understanding economic valuation of biodiversity.

The conceptual framework shows how the life-supporting ecosystem services provided by biodiversity are difficult to value economically, and that this leads to biodiversity loss globally. However, this can be prevented through PES systems, the difficulty lies in making this work in practice.

4 Method

The methodology chapter presents the research design underlying the methodology, as well as a description of the literature review, the case study and application of a hypothetical credit system, a description of data collection and analysis followed by quality assurance and finally ethical considerations that have been considered.

4.1 Research design

This study aims to investigate the economic, biological and social conditions for establishing the biodiversity credit system in Yayasan Sabah's Forest Management Area. The study was conducted as a qualitative case study with an abductive approach.

The study includes parts that can be categorized both as qualitative and quantitative: The literature reviews, interviews, observation study and analysis of audio recordings are of a qualitative nature, while the collection of numerical species data is of a quantitative nature (Bryman et al. 2017).

To balance the qualitative and quantitative components, a flexible research design was therefore pursued. Robson and McCartan (2016) describe how flexibility in a research design allows a design to evolve and take shape as data is collected. This allows the theoretical framework to be refined and supplemented based on the outcome of the data collection, which promotes good quality for the study.

To enable a flexible design, an abductive approach was therefore chosen. Abduction oscillates between theory and observation, not as in deduction where theory goes to observation or observation to theory in induction (Robson & McCartan 2016). Abduction aims to produce an explanation, hence the derivation of a question (Paul 1993). In an abductive approach, the study is derived as a logical consequence of the theory.

4.2 Literature review

In order to be able to present a good quality study, a review of previous studies is essential (Robson & McCartan 2016; Bryman et al. 2017). A literature review is an effective way to supplement the research object where possible shortcomings may occur (Robson & McCartan 2016).

The literature consisted mainly of scientific publications and official documents and were collected through searches via databases intended for scientific sources such as Google Scholar, SciSpace and Web of Science. Key phrases such as "financial compensation for biodiversity" and "credits for biodiversity" were used to limit the search results. A researcher in the field also shared a literature list, which was a valuable contribution to the literature study. The literature list included government documents, publications of regulations and laws, and scientific reports. Books related to methodology and scientific writing were also provided by the university library. Publications and reports describing natural resources, forest area, management practices and other relevant information about the case study site were provided by the co-supervisor. Secondary sources such as websites and journal articles were also reviewed.

The statistics presented are mainly taken from national government statistics, international research-based organizations and internal statistics of the organization that is the subject of the case study.

4.3 Case study

Robson and McCartan (2016) describe how a case study refers to a research investigation of an empirical nature, conducted with a strategy that aims to study an authentic and contemporary phenomenon. The study should be able to provide evidence from multiple sources. The phenomenon, or case, can be, for example, an environment, organisation or individual that is studied regarding its context *(ibid.).*

Furthermore, Robson and McCartan (2016) describe a case study as a flexible design where usually both qualitative and quantitative data are included. It is also common for the study to include more than one method of data collection.

A case study is appropriate when analysing a complex phenomenon where the boundary between the case in question and its context may be somewhat blurred (Robson & McCartan 2016; Yin 2008). Yin (2008) explains that a case study may involve a low level of predictability in particular events and outcomes, and that the study is expected to put more emphasis on investigating questions such as how and why.

The study was conducted as a case study as it aims to investigate a complex concept in the sense that it is a not yet widely established concept where the framework of the context can be described as diffuse, but where real and localized conditions for the phenomenon were investigated to answer the research question. Since it was unclear at the time of data collection what the outcome of these would be and how well they would be able to answer the question, a flexible design was sought with the possibility of being able to complement practice with theory. A case study was therefore considered appropriate because the major focus of the study was to investigate the concept of biodiversity credits functionality given the authentic conditions, while less control in its outcome was available.

The design of the case study corresponded to a single-case design with a holistic approach (with regards to a single unit of analysis) (Yin 2008). Based on a review of previous studies, it appears that there is no case study that examines the conditions for biodiversity credits at a state-owned forestry organization. Yin (2008) describes that it is justified to use a single-case design for studies that have not previously been scientifically scrutinised. The reason for this is that only the information itself that emerges from the investigation is revealing. Examining a single case can thus stimulate further research on the subject.

When conducting a case study, a Case Study Protocol is very helpful, and is also particularly important to consider as it can have an impact on the outcome of the study (Yin 2008). The function of the protocol is to guide the researcher during data collection, and to promote the credibility of the study as it provides a project overview.

Brereton et al. (2008) reviewed several well-cited case study publications and constructed a protocol template based on basic case study techniques. The protocol should include background on the research topic, description of the case study design, documentation of data collection and analysis and a validation plan. A Case Study Protocol was prepared and can be

found in Appendix 1.

To conduct a case study, some risks need to be considered. Yin (2008) describes that a general risk with a flexible design as a case study of the above described nature allows, is that subjective perceptions may influence the results. Another risk often associated with case studies is that a case study, precisely because of its flexibility, is not considered solid as it lacks a structured design, the researcher therefore has an important responsibility to structure the work to promote quality *(ibid.).*

To summarise, a case study with a single-case and flexible design was chosen in order to be able to complement the outcomes of the data collection with theory and to be able to focus on the "how and why" of the study rather than its outcomes, and at the same time promote good quality for the project. In the execution of the case study, the above risks were considered, including through the support of the case study protocol.

Selecting a unit of analysis was guided by method literature and practical settings in the project. Robson and McCartan (2016) describe that in a flexible research design, it is the purpose of the study that frames the unit of analyse. In this study, the purpose was to investigate the conditions for the concept of biodiversity credits in Yayasan Sabah Forest Management Area in, thus constituting the unit of analysis for the study. Robson and McCartan (2016) also describe that in a holistic single-case study, one institution can be the object of the case study. Since Yayasan Sabah's Forest Group is a department under Yayasan Sabah group which is a state agency under the state government of Sabah, the condition of institution as the unit of analysis for the study was fulfilled.

4.4 Application of hypothetical credit system

In the following section, a credit system was reviewed to examine hypothetically whether the system is applicable in the organisation that constitutes the unit of analysis for this study.

Case studies are useful when a phenomenon to be investigated cannot be clearly linked to an existing theory, and to further specify the framework of the case study, a hypothesis can be used (Levy 2008).

4.4.1 Bloom Labs – Database voluntary biodiversity financing

The research based website Bloom Labs (Gradeckas 2024a), was introduced in the background chapter. To find a suitable organization that could be studied to investigate a hypothetical credit system, the database of all established organization engaged in the global voluntary biodiversity financing was used. The total number of organizations amounts to almost 450. If the number of organizations was limited to those categorized under forest and biodiversity, the number was reduced to 16 organizations. Further, the number could be reduced to 9 organizations that operates under a specific biodiversity crediting system and under a certain standard.

To delineate the investigation and to best answer the purpose of the study, as well as to consider the organizational conditions of the case study object, one organization and its methodology for biodiversity credit system was chosen to be examined to examine whether the methodology could work in the organisation.

In the following section, a globally operating and reputable organization that has its own crediting and verification system for biodiversity credit standards, and that matches the conditions of the case study, was investigated.

4.4.2 Plan Vivo Foundation

Plan Vivo Foundation (PVF) was chosen to be examined. PVF is a global charitable organisation that operates under a credit system and an established standard for biodiversity credits (Plan Vivo 2020). The organisation aims to promote ecosystems, mitigate climate change and reduce poverty by supporting rural communities worldwide. In particular, the organisation works to support communities on the frontline of mitigating the climate crisis by applying the 'Plan Vivo' concept. The concept involves building local competences by carrying out local projects on the theme of climate impact and biodiversity. The organisation issues two different standards that can then be used to issue certificates, which the projects can claim and then sell as a credit to finance the project and further work. The organisation is well established in the field and has over 20 years of experience in carbon sequestration certification and has now chosen to also include a standard for biodiversity *(ibid.).*

The biodiversity standard is governed by a biodiversity strategy, PV Nature (Plan Vivo 2023a). Furthermore, there are two types of certificates that can be issued under PV Nature's standards: Conservation Certificates, which are awarded through the protection of areas of global biodiversity significance. The second certificate is a restoration certificate which is issued through the restoration of destroyed biological systems *(ibid.).*

To quality assure the standards and the issuance of the certificates, seven pilot projects have been carried out where actual projects to promote biodiversity and climate change have undergone a full process and application according to Plan Vivo's criteria, methodology and standard (Plan Vivo 2023a).

4.4.3 Requirements for PV Nature Standard

Vivo, through PV Nature, outlines several main criteria that a project must fulfil to be eligible for certification (Plan Vivo 2023d). Firstly, retroactive crediting is not allowed, so the project must either be ongoing or planned for the near future, with some adjustments for already initiated projects based on PV Nature's methods. The focus of the project must be to restore and/or conserve biological environments in a positive way, avoiding scenarios where it starts from a very low baseline (as in barren land) or results in biodiversity loss. Also land degradation over the last decade is not permitted within the project *(ibid.).*

A designated project coordinator is required who is an established legal entity with a significant local presence and the ability to manage resources, engage participants and liaise with stakeholders, institutions and authorities. The land involved must benefit both the project and the surrounding community, be managed through clear agreements, not lead to land being taken from smallholders or negatively affect their situation and involve local community representatives in management *(ibid.).*

Plan Vivo emphasises collaborative partnerships that benefit the local community and allow both local and external participants, if the local community is prioritised. There must be a clear understanding of land ownership and user rights, preferably documented and legally recognised by the government. The project should promote the growth of native species, improve livelihoods and/or provide other long-term benefits to the local community, contribute to one or more ecosystem services and clearly strengthen ecosystems *(ibid.).*

4.4.4 Validation and verification

Plan Vivo requires validation and verification of projects (Plan Vivo 2023e). This ensures projects follow the design document and PV Nature standard. There are two validation and verification approaches:

1. The project contacts an approved Validation and Verification Body (VVB). Plan Vivo lists approved bodies.
2. The project engages an independent expert appointed by the Plan Vivo Foundation.

Projects must be verified within five years of registration and every five years after, maintaining PV Nature guidelines. Verification can be done by a VVB or an independent expert. Plan Vivo provides detailed requirements for these bodies and experts *(ibid.).*

4.4.5 Methodology and documentation for certification

Plan Vivo presents a methodology for achieving certification based on the PV Nature standard, as well as a description on how biodiversity measurement data is collected and assessed (Plan Vivo 2023c).

Biodiversity measurement parameters

The methodology for converting biodiversity data into PVF certificates is summarised with five biodiversity metrics that need to be achieved *(ibid.):*

Species richness: Species richness describes the number of unique species represented in a geographically defined biological area. The higher species richness of an ecosystem, the better resilience and functionality of the ecosystem. Species richness reflects how a biological area recovers from disturbance or degradation, as recovery creates more habitats and allows more species to occur. Species richness, on the other hand, does not consider the distribution or abundance of species.

Species diversity: Species diversity includes both the number of species (species richness) and the relative abundance of each species (species evenness). Species diversity is important to study as it indicates how well a biological area is recovering from the effects of degradation, as a change in the relative abundance of species can be expected. Generally, the distribution shifts from, in a degraded environment, a small number of dominant species to, in a recovered environment, more numbers of species with an even distribution.

Taxonomic dissimilarity: Taxonomic dissimilarity is a measure of how closely related, similar or dissimilar species are in terms of their taxonomic distribution. It is also an important measure because healthy environments, with heterogeneous habitat structure and diversity, tend to have a greater range of taxonomic groups, while less healthy and more homogeneous environments tend to have a smaller range of taxonomic groups.

Habitat health: Habitat health describes the structural organisation of the ecosystem and the species groups present. In simple terms, a higher level of biodiversity means a higher quality habitat. This means that the ecosystem can provide more species, more microhabitats, offer a wider range of ecosystem services and be more resilient to natural disturbances. There is no general method for measuring habitat health because the structural buildup of ecosystems differs in different environments. PVF is working to study how terrestrial habitats change.

Habitat spatial structure: The spatial structure of a habitat means the extent of structural variation in the ecosystem, which correlates with the degree of biodiversity. The ability of a biological area to sustain biodiversity increases if the islands that make up the habitats in the area are larger and more connected *(ibid.).*

Steps of the methodology

Furthermore, the PVF presents a framework for how to conduct data collection and protocol for the above metrics. The method of collection aims to make an assessment over time at site level. The data collection methodology is presented in five overall steps and described as minimum requirements to fulfil the certificate standard, it includes: Sampling design, data collection, species identification with software tool or human expert, control of quality by human expert and calculation and valuation of metric values - done by PVF *(ibid.).*

Overarching sections for data

The framework presented above is followed by four overarching sections for data collection that are needed to fulfil the requirements: Species occurrence, relative abundance of species, extent and type of habitats found within a biological area, local environmental conditions (such as weather and local climate, during the period of data collection) *(ibid.).*

Collected data requirements

Furthermore, the collected data also needs to fulfil certain requirements for the certification to be achieved: To reflect the general trend of biodiversity at the site, data collection must cover a sufficient taxonomic range and/or groups of species. This means including several groups in the data collection, with data on at least four different target groups such as flying insects, medium and large mammals, birds, herbaceous plants, and woody plants. Methods used should allow for the calculation of the probability of detection of species to minimize classification errors. Sampling should be conducted on a sufficiently large spatial and temporal scale to allow for statistical conclusions, which requires an updated habitat map of the area to ensure adequate coverage *(ibid.).*

Data collection methods should be robust against failure caused by human factors such as bias or measurement error. This can be achieved by ensuring the method is fully repeatable and that measurements are taken by independent practitioners. Additionally, if the method is repeatable, trends in biodiversity change can be identified. The collected data must be fully auditable and of high integrity, requiring digital recording, inclusion of spatiotemporal metadata (such as coordinates), and independent quality checks. This step is essential for third-party verification of the data *(ibid.).*

4.4.6 Project requirements

Plan Vivo provides a detailed guide on how a project should be designed to be in line with PV Nature's requirements (Plan Vivo 2023c). The guide is divided into five main categories: Eligible Interventions, Stakeholder Engagement, Project Design, Monitoring and Reporting and finally Governance and Administration. The PVF believes that if the guide is followed, there should be no problem for a project to fulfil the requirements of the standard.

The 35-page guide was too extensive to be reproduced in its entirety, but some general points that are important to be able to initiate the process at all were presented below *(ibid.)*:

1) The project must restore and/or conserve land and promote biodiversity in the long term; the project must also contribute to climate, socio-economic and environmental benefits
2) The project and its interventions must contribute to socio-economic benefits beyond the scope of the project and the sale of certificates.
3) The project cannot be implemented on land that has been degraded intentionally from a biological ecosystem point of view over the last ten years through agricultural or similar land use *(ibid.)*.

4.5 Data collection

To summarise, the data collection consisted of tree data collection, species data collection through audio recording, observation study and a complementary interview study. The tree and audio recording data aimed to provide an overview of how biodiversity differs in the different land areas. The observational and interview study aimed mainly to investigate the social and organisational factors.

4.5.1 Tree data

The first part of the fieldwork consisted of collecting tree data through an objective inventory. The tree data was collected by placing 27 sample plots in as many different geographical areas in Yayasan Sabah's Forest Management Area. The plots were constructed at 40 x 40 meters divided into four smaller subplots of 20 x 20 meters (Figure 3).

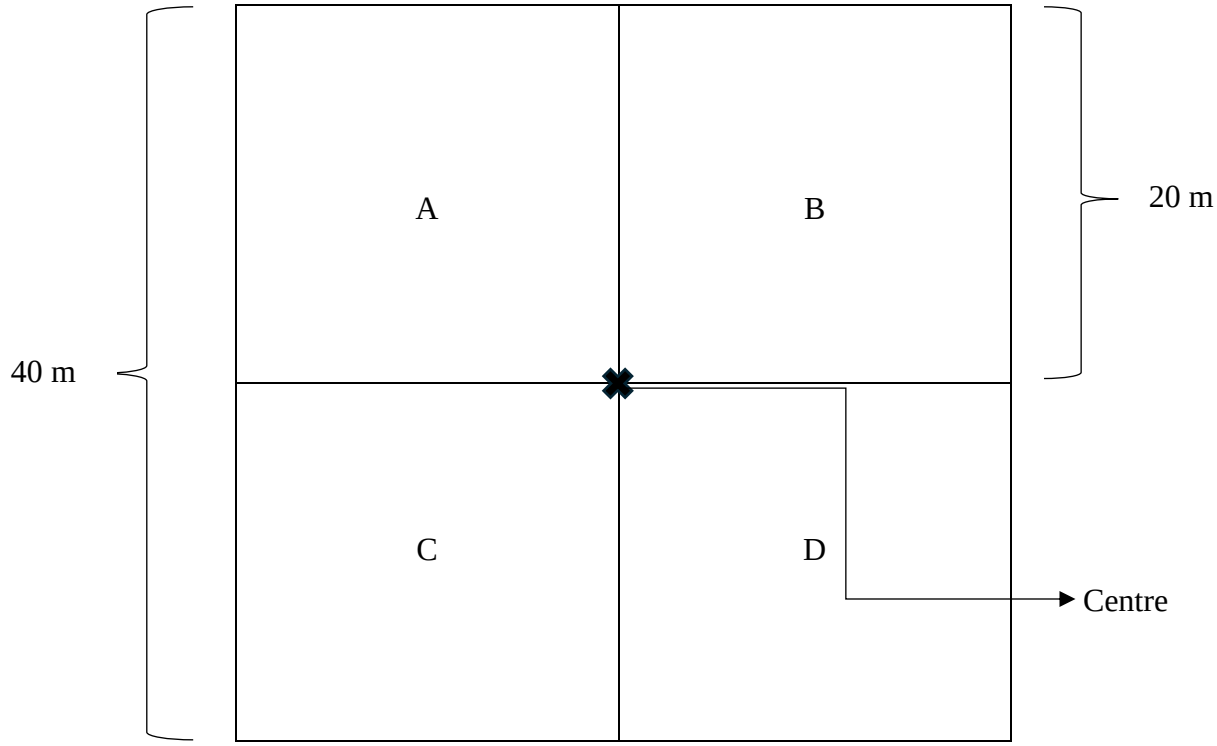

Figure 3. Illustrates how sample plots for tree data collection were constructed.

For each sample area, a centre point was placed where coordinates were also collected. The sample area was then measured in four smaller sub-areas with the centre point as a starting point using pre-measured line cords; a compass was used to keep the correct course when

measuring. Each subplot was given a code according to A, B, C and D and the plots were named in numerical order as they were carried out, Plot 1, Plot 2 and so on (some sample plots were named after the area and old plot names).

The sample plots were placed by first placing them on a map to ensure even distribution across the different areas. Since the surrounding conditions, in addition to the known method for the area, for the sample plots were unknown, the sample plots could be considered random, which was important to counteract bias. The sample plots were then searched using GPS.

In each plot, all trees with a diameter at breast height (dbh) of ≥ 10 cm were measured and labelled. Dbh is measured at a height of 1.3 meters except for trees with so-called buttresses (superficial roots that raise the trunk of the tree), where diameter was measured 30 cm from the highest buttress. For each tree, the tree species was also noted; information on tree species was provided by the field staff. Where relevant, it was also noted whether the tree was planted or not and whether the tree was found on the planting line (whether planned or self-rejuvenated).

All tree data were recorded in a written protocol and then transferred to an electronic document.

The land areas (meaning natural, degraded and restoration area) in which the sample plots were placed were:

- **Wathershed Reserve**. Representing natural (pristine) forest, which means that the forest is completely untouched. Here **6** plots were carried out.

- **Degreaded corridors**. Representing degraded forest, which means that the forest has been harvested about 20 years ago but has since been left untouched. Here **7** plots were carried out.

- **INIKEA** - Forest Rehabilitation Project, representing different phases of active restoration: -**Phase 1** (restoration between 1998-2003) – **10** plots were made here.

- **SUAS** - Representing natural (pristine) forest. Here **4** plots were carried out.

This gives that **10 plots** in natural forest, **7 plots** in degraded forest and **10 plots** in restoration area were carried out.

The original plan was to establish an equal number of sample plots in the different land areas, but due to unforeseen events, changes in planning and inaccessible areas, only the above sample plots could be sampled.

4.5.2 Audio recording

The second part of field data collection consisted of collecting passive acoustic monitoring (PAM) data using AudioMoth acoustic loggers (Open Acoustic Devices n.d.). The audio recorders collected animal sounds mainly from birds, but also monkeys amphibians.

The audio recorders were deployed using the same objectively placed test plots as established for the tree data, the audio recorders were placed at the centre of the test plot. In addition,

audio recorders were also placed in a eucalyptus plantation near the Yayasan Sabah Forest Management Area and in phases 1 and 4 where no tree data were collected. The audio recorders were placed slightly above chest height (1.3 m) in a tree in a waterproof sealable package that was tied up with sturdy steel wire. They were left to record for 10 days before being taken down for analysis. The recorders were recorded 24 hours/day at an interval equivalent to 1 minute of recording and 4 minutes of rest per 5 minutes.

The land areas in which the audio recorders were placed were:

- **Wathershed Reserve**. **3** recorders - one in each plot (one broken, therefore 3).
- **Degreaded corridors**. **3** recorders - one in each plot (one broken, therefore 3).
- **INIKEA -Phase 1**. **6** recorders.
- **Sabah Softwood Berhud** - Eucaplyptus plantation. A bit from Yayasan Sabah's Forest Management Area is Sabah Softwood Berhud, which does not belong to the Yayasan Sabah group, it is a private organisation. Here, **8** recorders were placed in 8 different stands of different ages (from 2-10 years) of planted eucaplyptus. The reason why the audio recorders were placed in the plantation was to enable comparison of data from conventionally managed forest with the restored parts of Yayasan Sabah's Forest Management Area. It was not allowed measure tree data in the plantation so only sound recordings were measured.

4.5.3 Observations

An observational study is a study based on passive perception and observation in the environment where the subject of the study is naturally occurring (Merriam & Tisdell 2015). An observational study is useful when a current and fresh perspective is desired and is an effective complement to an interview study or other documentation. The observation should represent data that constitute a first-hand encounter with the object of observation, hence the observation data should not be generated from a second hand observation *(ibid.).*

Observation studies are commonly used in qualitative research and mainly occur as action research or ethnographic research. In action research, the researcher is distanced from the object of observation, while in ethnographic research the researcher integrates with the object. In view of the project's purpose and research questions, ethnographic research was conducted *(ibid.).*

An ethnographic study occurs when the researcher keeps a detailed documentation of the object of observation, the surrounding environment and the people involved. The author describes the documentation as a field diary that includes the researcher's experiences, thoughts, mistakes and concerns about the research method and the object of observation *(ibid.).*

Merriam and Tisdell (2015) describe how an observation study consists of three stages. The first stage involves entering the place that constitutes or where the object of observation is located. This may involve gaining formal or legal access but also establishing trust with the people involved. The second step involves the data collection itself. It is important to keep as detailed a record as possible, and it is particularly important to document what is relevant to the study in question. The third and final step involves ending the presence at or in the object

of observation in a respectful manner. This may involve informing the people involved how the data will be analysed and presented and thanking them properly. In practical terms, it is also important to register the observations made during data collection as soon as possible after the end of the observation to minimize the risk of losing important details. This may involve digitizing field notes or coding and categorizing the observations to facilitate analysis *(ibid.)*.

An observation study was carried out in accordance with the above description where the researcher accompanied the field staff to the observation site. Daily field notes were taken of the observed observations and included among other things how the surrounding environment looked, vegetation and accessibility in the forest, how the staff worked to identify the trees, the road network between the forest stands, observations of animals, safety aspects and risks.

4.5.4 Interviews

A semi-structured interview design was chosen for this project to complement its abductive methodology, providing necessary flexibility (Robson & McCartan 2016). A semi-structured interview means that the interview is expected to follow a certain order and cover topics relevant to the study's research questions, but that the order and nature of the questions may change depending on the progress of the interview or the characteristics of the respondent *(ibid.)*.

The interview was held with two respondents who work in the organisation but in different departments. The questions were constructed to reflect the research questions based on their professional responsibilities and experience. (Appendix 2 interview).

Two of the interviews were held orally and were recorded to be transcribed. The interview form consisted of a front page with information on how the interview would take place, what the material would be used for and the rights of the interviewee, followed by a short information text about the topic of biodiversity credits with authentic examples and then a page with the actual interview questions. To avoid misunderstandings due to language barriers, the information and questions were available in both English and Malay. The interviewee could choose to answer the questions in English or Malay. The digital tool Transkriptor (Transkriptor 2024) was used to transcribe the audio recordings. Where Malay was used to answer the questions, the tool transcribed into Malay and was then translated into English using the digital translation tool Google translate.

4.6 Data analysing

4.6.1 Species data analyse

The collected species data consisting of tree data as well as audio recording data were first categorised in the spreadsheet tool Excel. Each individual (tree or animal) was represented and categorised according to temporal, spatial and species-specific information.

Species richness and species evenness was then estimated to examine whether biodiversity was measurable in the different land areas. Species richness is the number of species in a geographic area defined by the observer or researcher, while species evenness is the relative abundances of species (Hooper et al. 2005). Species richness and species evenness was estimated by calculating the number of found species, for species richness and by calculating every individual for all identified species for specie evenness. This was made for each sample plot in each area, by using the Excel spreadsheet tool.

Since the species data represents several different areas consisting of different sample plots each, the mean value for species richness and species evenness for each land area was then calculated. The main advantage of studying the mean is that it represents the dataset well as it considers all values (Manikandan 2011). The mean is described as a measure that is most appropriate in terms of avoiding variation between samples, as repeated measurements at the same site or population usually generate similar means. The main disadvantage, however, is described as its sensitivity to extremes or disturbances and is therefore suitable for evenly distributed values *(ibid.)*.

The calculated mean value was then used to compare the species richness of the different areas. One of the most reliable and easiest ways to compare biodiversity between different areas is to compare their species richness because the calculations are simple, the pitfalls few and the numbers self-evident (Melo et al. 2003). Furthermore, it is described that the most important thing in such a comparison is that the size of the sample plots is the same to avoid bias. The size of the sample plot and the conditions for the audio recordings were the same for all plots. In cases where there were different numbers of sample plots in the different land areas, the mean was adjusted accordingly.

In the comparison, the pristine area was considered as a 'zero value', meaning that it was expected to be the level of biodiversity that can be assumed to be the most likely in untouched forest. It is against this baseline that the other land areas were compared.

Finally, bar charts were constructed using the Excel spreadsheet tool to help visualise the species richness of the different areas.

4.6.2 Thematic analysis

To analyse the observation material and the interviews, a thematic analysis was performed.

One of the main advantages of a thematic analysis is its flexibility (Braun & Clarke 2006), which fits well with the abductive approach chosen for the work.

A thematic analysis is a methodology that aims to identify, account for and explore recurring themes and topics in the data collected (Braun & Clarke 2006). The authors describe how the flexible design and theoretical openness of the thematic analysis can facilitate a complex and yet detailed analysis of the data. At the same time, the challenge of a thematic analysis can be derived from its openness and the authors emphasise that a good balance between flexibility and delimitation is important when analysing *(ibid.).*

The model for thematic analysis presented by Braun and Clarke (2006 p. 16-23) consists of six phases. The authors describe that the practitioner should work with the different phases in a flexible way by switching back and forth between the different phases rather than as a fixed process.

The first stage involves familiarising the researcher with the data collected. This is important even in cases where the researcher has been involved in collecting the data, as in the case of this study. Although it can be time-consuming, Braun and Clarke (2006) recommend repeated reading to be able to initially identify different themes. First of all, the material was transcribed, and a careful review was then carried out, and some overarching themes were first identified. The next steps included identifying themes and patterns in the material

through coding. Coding was carried out through colour coordination, with each identified theme represented by a colour code. Once the colour coding was completed, different patterns in the identified themes could be discerned. This step was followed by a review of the identified themes and patterns to correct and specify further in the material. The next step included naming and characterising the different themes more clearly. The final step consisted of qualitatively including the identifying themes in the rest of the study's analysis to answer the research questions of the study *(ibid.).*

4.6.3 Analysis using hypothetical credit system

The final step in the analysis involved applying the summarised analysed results of the species and thematic data within the framework of the hypothetical credit system presented earlier in the methodology section.

4.7 Quality assurance

Merriam and Tisdell (2015) describes how research is about delivering reliable and quality knowledge. The reliability of a research result is related to the level of rigour with which each step of the study was carried out. In qualitative research based on hypotheses, it is particularly important to be able to quality assure the results.

In their book, Merriam and Tisdell (2015 p.19) present a strategy comprising eight steps that can be followed to promote reliability and validity in a study. These steps will be reviewed and then a description of how each step was followed in quality assurance of the study. This will be presented in a table below (Table 1).

Table 1. Eight steps to promote reliability and validity have been followed for the quality assurance of the study

Step to promote reliability and validity	**How it was followed in this project**
1. **Triangulation** - Involves using more than one data collection method or data source to investigate the research questions.	This was accomplished through four different data collection methods, two different species data: tree data and audio recording data, and two different types of thematic data: observational study and interview study.
2. **Member checks/respondent validation** - Involves checking interpretations and results against people or objects they are derived from to evaluate their plausibility.	Included the thematic studies. Step two was carried out by checking that information and descriptions of activities presented in interviews were correct and giving the interviewee the opportunity to check the accuracy of the statements. In the observation study, a constant dialogue was maintained with the fieldworkers involved to check that observations concerning, for example, the surrounding environment, observations of animals, etc. were reasonable in terms of their expertise and experience.
3. **Adequate engagement in data collection** - Means that engagement in data collection is expected for a credible result, meaning that the researcher is involved in ensuring that the data is sufficiently representative and that, for example, comparators with expected negative outcomes are included.	The researcher was directly involved in all data collection, so no data was provided retrospectively. The researcher was involved by collecting species data and observational data from a large geographical area of biological variation to compare results. For example, audio recording data was collected from a eucalyptus plantation with expected lower biological diversity to compare with other areas.
4. **Researcher's position of reflexivity** - The researcher should reflect on assumptions and research results in a critical way.	In the thematic study, especially in the observation study, the experiences were discussed with the field staff and others to ensure that the observations were not only experienced by the researcher. During the interview, a pilot study was conducted before the actual interviews were held to avoid leading questions. The pilot study was conducted on a student with some knowledge of the subject of biodiversity credits and forests.
5. **Peer review/examination** - Continuous scrutiny of the study process to ensure that the emerging conclusions are consistent with the initial interpretations.	The flexible design has allowed the emerging findings to be interpreted, checked and complemented with the theory and literature section.
6. **Audit trail** - implies that there should be a detailed record of the methods and approaches used to conduct the study.	The study was carried out through a step-by-step and well-thought-out plan, see research design. Each step was also documented in a case study protocol - See Appendix 1.
7. **Rich, thick descriptions** - A detailed description of the study that allows the reader to understand how the research context and results are compatible should be provided.	The researcher has conducted a literature review relevant to the study to present, as far as possible, a thorough introduction to the research topic in the theory review.
8. **Maximum variation** - The study will endeavour to achieve diversity and variation in the sample for the results to be as applicable as possible.	To the extent possible within the constraints of the project, variation and diversity have been sought and pursued. For example, interviews were carried out with employees from different positions within organisations, the observational studies were carried out comprehensively, not just around the collection of data.

The table shows how quality assurance measures were implemented in the study. Triangulation was achieved through four data collection methods. Respondent validation included thematic review and dialogue with fieldworkers. The researcher actively participated in data collection and used reflexivity to avoid biases. A flexible design and carefully

documented methods ensured scrutiny. Rich descriptions and diversity in the sample strengthened the reliability and validity of the study.

4.8 Ethical considerations

Ethical considerations should always be taken into account in research that involves people in any way (Robson & McCartan 2016).

An important part of ethical consideration is the consent of the persons involved to participate in the study Robson and McCartan (2016 p.214). To ensure this, the researcher should 1) explain what the study in question involves and what the person's contribution to the study is intended for; this can be ensured with an information sheet. 2) announce the request for a participant in sufficient time for the respondent to consider participating, preferably more than 24 hours beforehand. 3) ensure that participants have access to written information about their rights to participate (for instance, being able to choose to withdraw at any time during the process). 4) Finally, make sure that the participant has understood the purpose of the study and their role in the process *(ibid.).*

The ethical considerations presented above were applied mainly in the interview study and partly in the observation study, both involving human participants. In the interview study, the request for the interview was announced about two weeks before the interviews were conducted. At the time for the interview, the respondents were asked to read through the interview questions and information sheets before the interview started, and they also had access to the material in Malay to reduce the risk of misunderstanding. The interview then began with a review of the participation information, which was also available in the information sheet. The respondent was informed that participation was completely voluntary, even after the interview was conducted, and that it was possible to withdraw at any time during the process. There was the option to remain anonymous, as well as the possibility to choose not to answer any question and/or change or add to the answers at any time during the process. For the convenience of the participants, they were given the choice to answer the interview questions in English or Malay.

During the observation study, a dialogue was initially held with the organisation's manager to ensure that field notes would be taken and used in the study. All participants in the field were informed about the observation study and its purpose.

5 Empirical background

The following chapter present factual information that complements previous chapters in order to answer the research questions.

5.1 Biological environment, Sabah, Borneo, Malaysia

Malaysia is a nation located in Southeast Asia and consists of 13 states, including Sabah which is located on the north-eastern part of the island of Borneo (FAO 2020a). The total land area corresponds to 330 345 km2 and includes more than 876 islands.

Malaysia's forests have a unique flora and fauna with about 15,000 estimated species. With its complex composition of ecosystems, Malaysia is considered one of the world's megadiverse countries (FAO 2020a). Megadiversity is found within countries that possess the majority of the world's natural resources (ACCIONA 2019). Global biodiversity is therefore not evenly distributed across the globe; some countries have a greater amount than others. These include countries in the tropics, with a total of 17 countries providing habitat for between 60-80 % of global biodiversity. The megadiversity classification aims to provide a framework for decision-makers and policymakers to allocate resources to promote these valuable assets *(ibid.)*.

A significant proportion of the valuable diversity associated with Malaysia can be found on the island of Borneo, the world's third largest island. The tropical forest region of Borneo is believed to harbour some of the world's oldest forests, and according to figures from the World Wildlife Fund (WWF), approximately 6% of the world's total global diversity can be found on Borneo (WWF 2024). Borneo's forests are inhabited by important species such as proboscis monkeys, orangutans and elephants, which have come to have great symbolic value for Borneo's wildlife.

The state of Sabah is described as the heart of Borneo in terms of the degree of diversity as a large part of the biological values can be found here (WWF 2024). More than 50% of the area in the state of Sabah is covered by forest where virtually all the forest is classified as evergreen tropical rainforest due to the state's location, which offers a humid, tropical climate (Sabah Biodiversity Center 2012). Sabah's forests are described as very diverse with unique plant assemblages resulting from the composition of particular soils, local climate and topography.

Even at the regional level, the state of Sabah offers diversity in terms of different types of forests as well as lowland and upland forests and swamp forests with different biological compositions (Sabah Biodiversity Centre 2012).

5.2 Yayasan Sabah Forest Management

The forestry organisation that serves as the unit of analysis for this study is part of the government agency, Yayasan Sabah Group, which operates under the Sabah State Government (Yayasan Sabah Group 2024c).

The group has a sub-group, Yayasan Sabah Forest Group, whose main mission is to manage forest concession areas in Sabah according to sustainable forest management (Yayasan Sabah

Group 2024b).

The management strives to fulfil environmental and financial parameters in accordance with the Sabah Forestry Department's standards. Furthermore, there is another sub-group specifically operating for conservation and promotion of biological environments, the Conservation and Environmental Management division (Yayasan Sabah Group 2024a). The division is responsible for a total of five conservation areas, including the Kalabkan Forest Reserve which forms the area of this case study. The division collaborates with several international organisations, such as the World Wildlife Fund (WWF) and the Swedish University of Agricultural Sciences (SLU) to conduct and offer education, research and training programmes in the rainforest environment. In particular, the group runs multi-year and large-scale projects for reforestation and rainforest restoration together with actors such as IKEA and several local actors *(ibid.).*

5.2.1 Rehabilitation projects

The study was conducted within the framework of the Innoprise-IKEA (INIKEA) Forest Rehabilitation Project in Kalabakan Forest Reserve. Kalabakan Forest Reserve is located in the southern part of the Yayasan Sabah's Forest management area, next to the community of Luasong, Sabah, Malaysia Borneo (Figure 4). The community of Luasong is important for the organisation where many of the employees live with their families.

Figure 4. Location of Luasong, Sabah, Borneo (SLU n.d.).

The figure above illustrated the geographical location of Luasong, which is central to the project activities and community involvement in the Kalabakan Forest Reserve and the INIKEA project. The Innoprise-IKEA Tropical Forest Rehabilitation Project (INIKEA) started in 1998 as a co-operation between Innoprise Corporation Sdn. Bhd. which is the investment company of the group and the Swedish Sow-A-Seed Foundation funded by IKEA together with SLU (Yayasan Sabah Group 2024a). The project aims to restore and promote

biodiversity in a forest area that was destroyed by an intense forest fire between 1982-1983 and logging, totalling 19,870 hectares. To date, the project has restored approximately 14 000 hectares. Since its start in 1998, the project has reforested the area in four different phases: Phase 1 (restoration between 1998-2003), phase 2 (restoration between 2003-2008), phase 3 (restoration between 2008-2013), phase 4 (restoration between years 2015-2024) *(ibid.*).

In the different phases, three main restoration methods are used: Gap-cluster enrichment planting (planting in gaps), line planting and release treatment (one-off treatment including ringbarking of pioneer tree species as a type of shade adjustment to favour other tree species). The different phases are treated according to one of the three methods depending on the degree of degradation: In case of severe degradation, either gap-cluster planting or line planting is applied, in case of minor degradation, release treatment is applied and in case of largely unaffected forest, it is left untouched. Currently, the project is in its fourth phase and a further 1600 hectares are expected to be reforested (*ibid.*).

5.2.2 Economic conditions

Philipson et al. (2020) present management costs for restoration in tropical rainforest, which are based on costs for a restoration project that is consistent with the INIKEA project, which have also been verified through dialogue with responsible staff with financial insight into INIKEA.

The costs involved in the management and restoration of tropical forests within the scale of Yayasan Sabah's Forest Management area and the INIKEA project is summarised in Table 2 *(ibid.).*

Table 2. Shows the tropical rainforest management and restoration actions with an associated description that is included in the management cost

Cost	Action description
Tree planting	A large part of the cost is derived from the planting itself which includes collection of seed material, raising of seedlings in nursery, care of seedlings and transport of seedlings to the planting site.
Climber cutting	This involves removing competing, climbing plants such as lianas that make it difficult for trees to establish.
Liberation thinning	Removing competing vegetation around young growing trees.

The table above presents the main costs and associating actions that are studied in the article. The costs are linked to actions related to active resource management and restoration measures aimed at promoting the emergence of new trees. But there are also other costs in the overall model that are not included in the table, such as: Labour and equipment, logistics, monitoring and follow-up, administrative costs and trainee-programme *(ibid.).*

The costs of restoration in the region in question, taking into account the above costs, are estimated to be approximately USD 1500-2500 per hectare, which is consistent with global estimates of tropical forest restoration (Philipson et al. 2020). The global average is estimated to be USD 1596 per hectare.

The article specifically studies how tropical forest restoration projects can accelerate carbon sequestration for climate mitigation (Philipson et al. 2020). An estimate of the price per tonne

of carbon dioxide equivalent to finance restoration costs is presented. The pricing model is expected to cover restoration costs over a 30-year period. To cover restoration costs of around USD 1500-2500 per hectare, a price of around USD 40-80 per tonne of carbon dioxide equivalent is needed *(ibid.)*. There are many studies, including (Wardle et al. 2012) that demonstrate a correlation between the degree of carbon sequestration and the degree of biodiversity. The price per tonne of carbon dioxide equivalent described above can be expected to be used in a calculation of the economic value of biodiversity.

In terms of income for the organisation, this consists of government funding as well as funding from local and global donors and partners that are directly linked to the restoration projects under the organisation's remit (Pius Pansang 2024). The funding covers the organisation's commitments in relation to the restoration mission, as well as salaries and staff costs for a total of 58 employees *(ibid.)*.

5.3 Financial requirements certification

The Plan Vivo Foundation that was examined in the hypothetical case study in the methodology section presents that there are some basic fees to register a project and then be able to apply for certification (Plan Vivo 2023b).

The costs are based on assumptions at the launch of PV Nature in December 2023 and will be reviewed and updated annually *(ibid.)*. The costs include:

-Personnel costs for Plan Vivo
-Cost of independent, external technical reviewer
-Costs related to independent third-party organisation to verify biodiversity data annually

Costs do not include hiring an independent validation and verification body for validation and verification *(ibid.)*.

Below is a list of all costs and associated fees presented by Plan Vivo (2023b):

-Eligibility checks = £250
-Project Idea Note (PIN) review = £1,500
-Project Design Document review (including one Technical Specification) = £8,000
-Technical Specification Peer review = £500 (per review)
-Tech Spec updates -Variable based on the scope of update
-Validation (at the start of the project) = £500
-Annual Reporting = £2,000
Analysis (annual) = £5,000 flat fee per project plus charge per hectare (this is variable by project size)
-Verification (at least every 5 years) = £500
-Late Annual Report fee = £100
-Issuance fees = <50,000 certificate = £0.30/certificate - >50,000 certificate = £0.25/ certificate

Then there is the project cost per hectare. Below are some price examples for cost (£ GBP) per hectare:

-500 hectares - £14
-1000 hectares - £10
-2000 hectares - £7
-5000 hectares - £4.5
-10 000 hectares - £3
-30 000 hectares - £2.5 *(ibid.).*

If Yayasan Sabah's Forest Group were to apply to register a project with the Plan Vivo Foundation equivalent to 1600 hectares, which is the area remaining to be restored in Phase 4 of the INIKEA project, this would equate to a total cost of approximately £31850. The cost has been calculated by summing the above costs including project cost of £8.5 per hectare for 1600 hectares and lower scale Issuance fees (<50,000 PVBC p.a = £0.30/certificate).

6 Results

This chapter presents the empirics from the four different types of data collected. In this chapter, the results will only be presented with some clarifications, no analysis will be made.

6.1 Species data

In this section, the empirical results for the species data, consisting of tree data and audio recording data, will be presented. With reference to the methodology, it is mainly the values for species richness that are of interest in a comparison between the different land areas' level of biodiversity. Pristine land area, representing untouched forest, can be considered as a 'zero value' in how the level of biodiversity (in this case, as mentioned, we are mainly looking at species richness) can be expected to look like under natural circumstances, meaning without the influence of human activity or other disturbance. This means that if the active measures carried out (phase 1) are considered to have succeeded in terms of the level of biodiversity, the value for species richness should be similar to or perhaps even higher than the zero value. Degraded land area and planted land area can hence be expected to have a lower level of biodiversity in terms of species richness.

For each diagram, two bars are presented representing (species richness and species evenness) a sample plot in the land area. The values for each sample plot then result in the mean values, which are those that will be used in the comparative analysis.

6.1.1 Tree data

A summary of species richness and species evenness based on the tree data is presented below. Each diagram represents one of the three analysed areas. S= Species richness N= Species evenness.

First the diagram of species values for degraded land area based on tree data is presented (Figure 5).

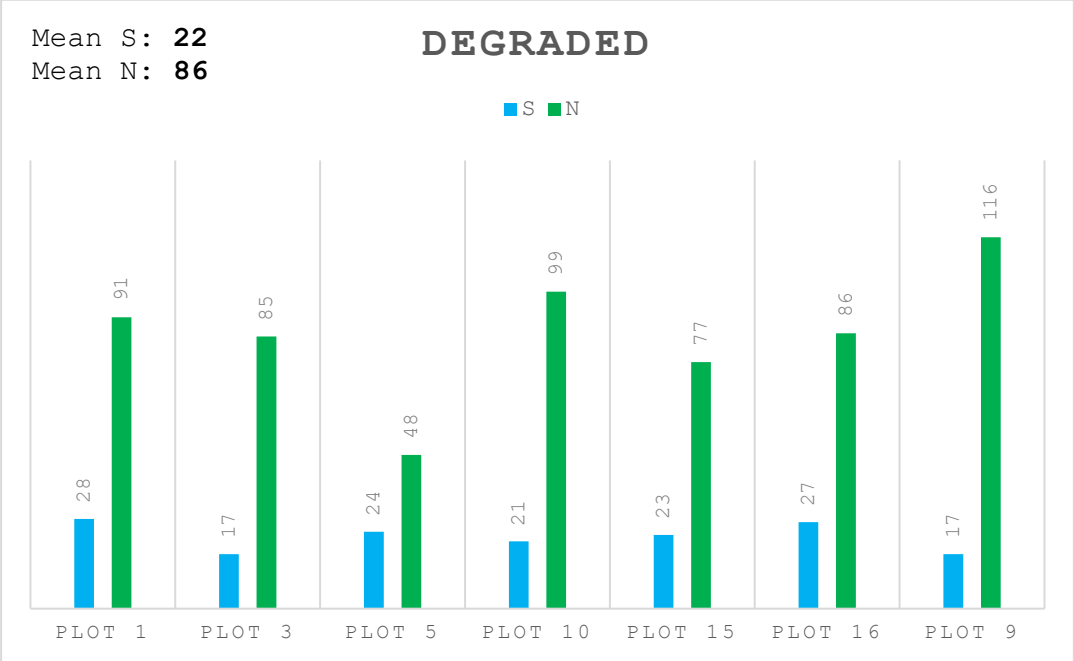

Figure 5. Diagram of the empirical results for tree data in degraded land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for degraded area demonstrates seven plots with a mean value of 22 species for species richness and 86 individuals for species evenness. Due to the nature of the measure, species richness is expected to be lower in numerical value than species evenness (this applies to all presentations of species data in this section). Some sample plots stick out, for example Plot 9 which has a high species evenness in relation to species richness - this is because some individual species had a much higher abundance than others in the sample plot.

Secondly the diagram of species values for pristine land area based on tree data is presented (Figure 6).

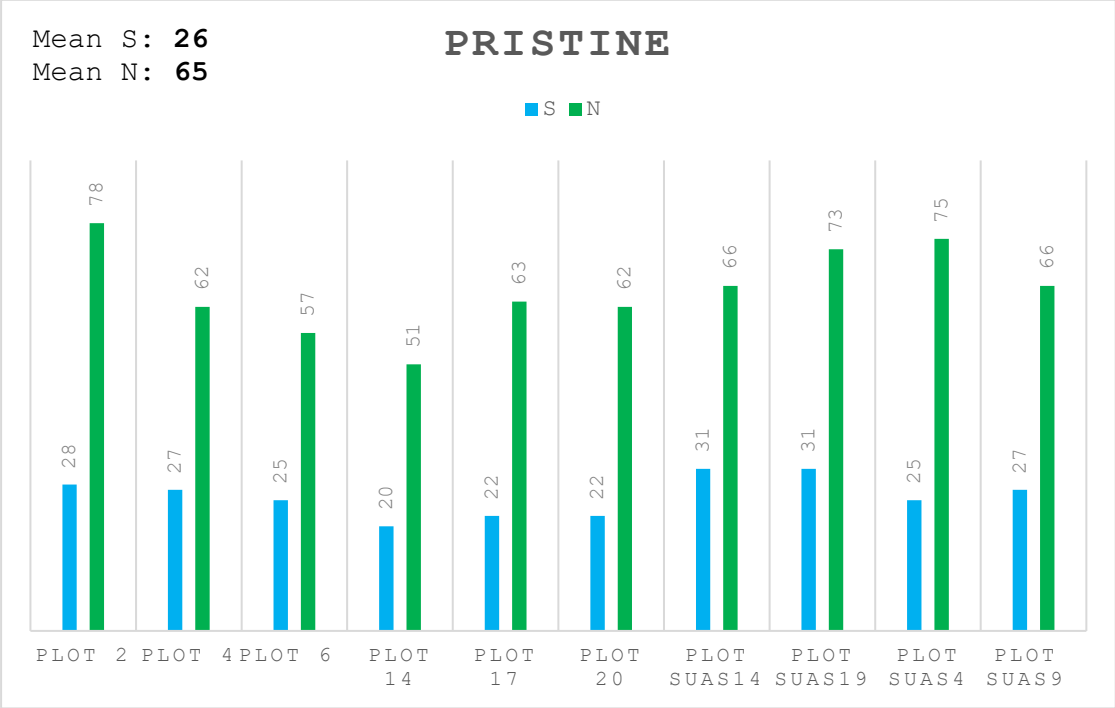

Figure 6. Diagram of the empirical results for tree data in pristine land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for pristine area demonstrates ten plots with a mean value of 26 species for species richness and 65 individuals for species evenness. For pristine land area the values are relatively evenly distributed despite the geographical dispersion of the land areas where the sample plots are located (the SUAS area is in a different part of the management area than the other sample plots).

Thirdly the diagram of species values for phase 1 land area based on tree data is presented (Figure 7).

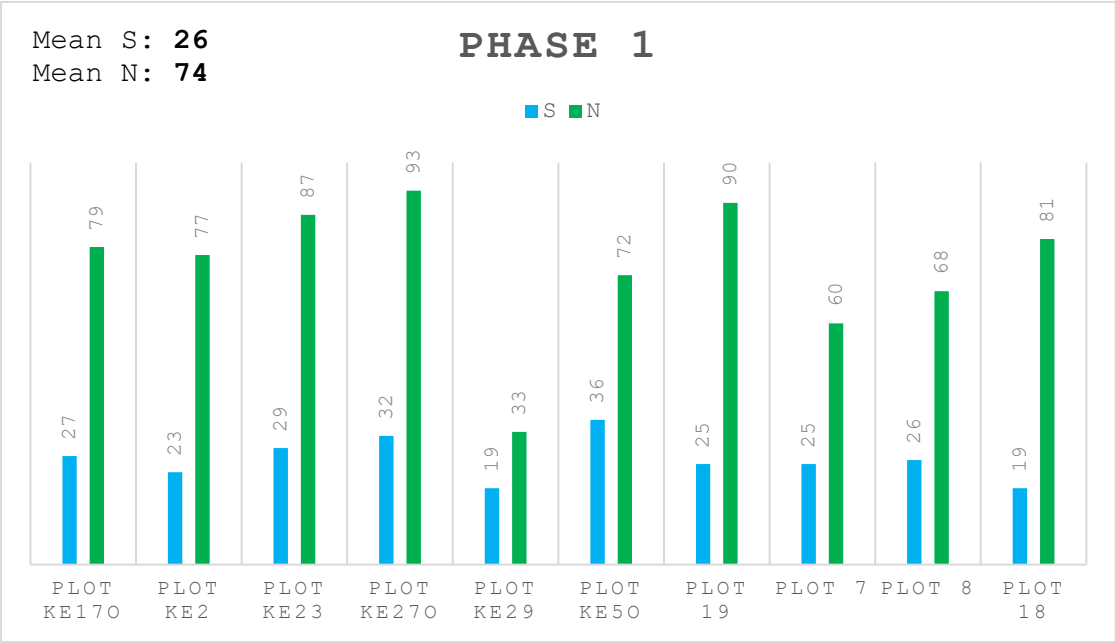

Figure 7. Diagram of the empirical results for tree data in phase 1 land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for phase 1 area demonstrates ten plots with a mean value of 26 species for species richness and 74 individuals for species evenness. Here, sample plot KE29 stands out compared to the others, because the number of individuals per species (species evenness) ranged from 1-3 individuals per species.

6.1.2 Audio recording

A summary of species richness and species evenness based on the audio recording data will be presented below. Each diagram represents one of the four analysed areas. S= Species richness N= Species evenness.

First the diagram of species values for degraded land area based on audio recording data is presented (Figure 8).

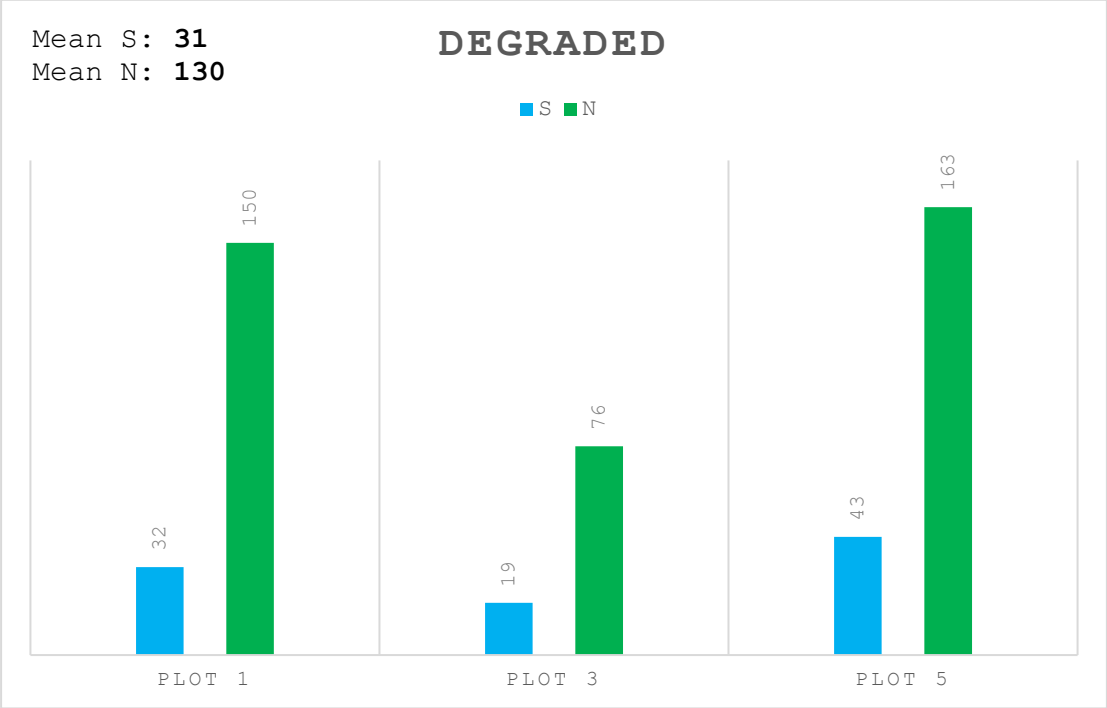

Figure 8. Diagram of the empirical results for audio recording data in degraded land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for degraded area demonstrates three plots with a mean value of 31 species for species richness and 130 individuals for species evenness. Here the distribution is uneven, which can be explained by the relatively low number of sample plots.

Secondly the diagram of species values for pristine land area based on audio recording data is presented (Figure 9).

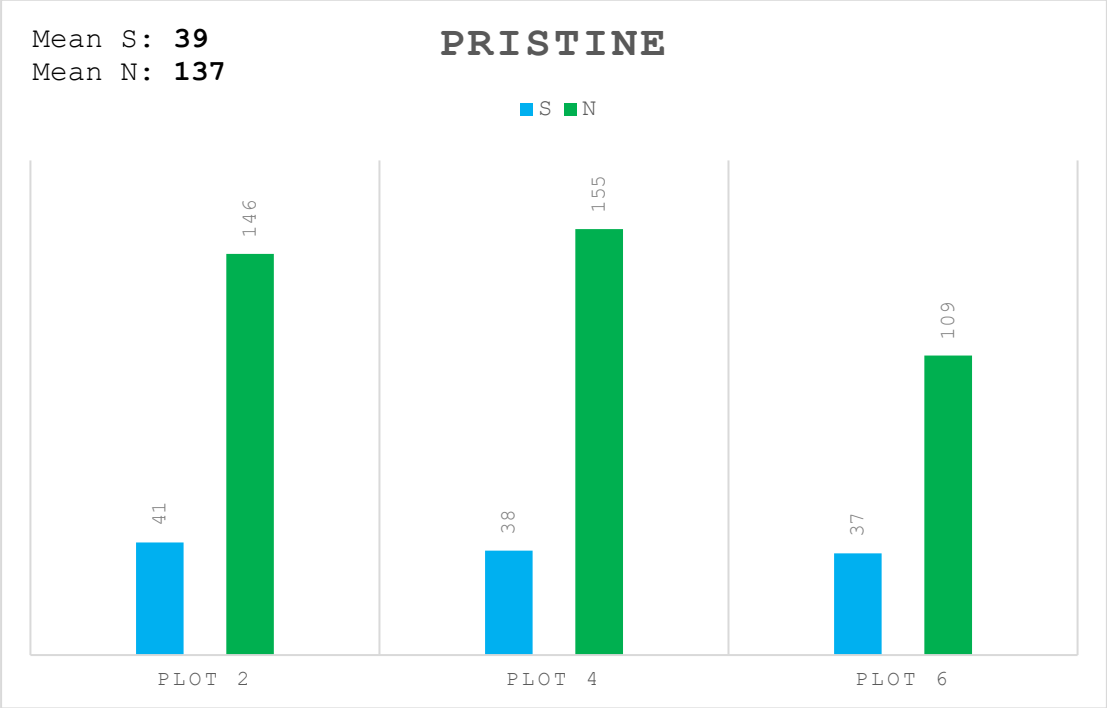

Figure 9. Diagram of the empirical results for audio recording data in pristine land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for pristine area demonstrates three plots with a mean value of 39 species for species richness and 137 individuals for species evenness. Here the distribution of values is more even, although the number of sample plots is relatively low.

Thirdly the diagram of species values for phase 1 land area based on audio recording data is presented (Figure 10).

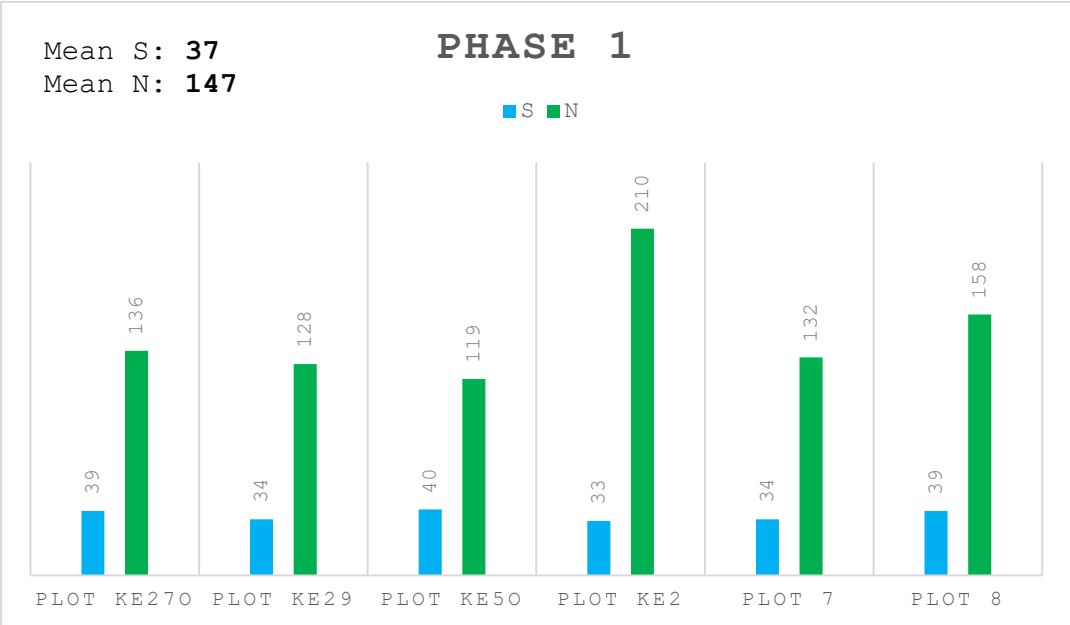

Figure 10. Diagram of the empirical results for audio recording data in phase 1 land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for phase 1 demonstrates six plots with a mean value of 37 species for species richness and 147 individuals for species evenness. Here, the distribution of values is more even between the sample plots with the exception of sample plot KE2 where the value for species evenness stands out. As above, some species have a much higher number of individuals than the others in the same sample plot.

Fourthly the diagram of species values for plantation land area based on audio recording data is presented (Figure 11).

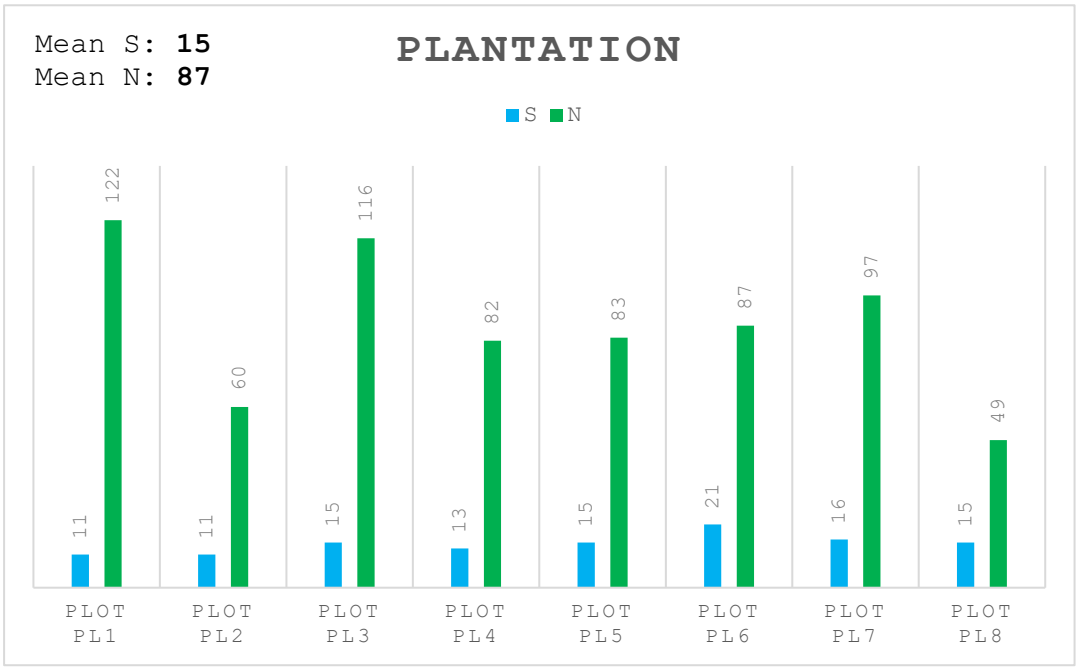

Figure 11. Diagram of the empirical results for audio recording data in planted land area, showing species richness S and species evenness N for all sample plots in the area and the mean values for the whole land area.

The diagram above for plantation area demonstrates eight plots with a mean value of 15 species for species richness and 87 individuals for species evenness. The plantation values show relatively high values of species evenness in relation to species richness, with some sample plots standing out. This is again explained by the fact that some species have a much higher number of individuals than other species.

6.2 Thematic data

The results of the thematic data are presented in tabular form for the observation study and in written form for the interview study. The two sets of data have been categorised for the convenience of the reader. It is primarily the part of the data that describes the social, organisational and economic conditions that is of interest with regard to the study's research questions and as a complement to the species data.

6.2.1 Observations study

The results of the observational study are summarised in a table below (Table 3), where the key observations are presented. The observation study is presented in full in tabular form and through free field notes in Appendix 3. The observation study and field notes are based on the researcher's own experiences.

Table 3. Shows a summary of the field notes taken during the observational study by date and category

Date	Activity	Forest type	Description	Access/Navigation	Safety & Risks	Species	Notes
8/3	Inventory	Degraded forest	Tree data	Difficult terrain	Leeches, first aid kit, rubber shoes	Snake	Illegal activity
11/3	Set up	Plantation (monoculture)	8 audio eucalyptus	Good road network	Roads	Wild boar, elephant,macaque, red leaf monkey	Heavy security
12/3	Inventory	Pristine forest	Tree data + audio data	Tough terrain, 2 km walk	Sharp slopes	Deer, sun bear, birds, wild boar	Language barriers
13/3 – 15/3	Inventory	Pristine/Degraded forest	Tree data + audio data	Varies by day	slippery, leeches, climbing	Wild boar, sun bear, macaque	Staff pride
18/3	Inventory	Pristine forest	Tree data + audio data	30 min drive, difficult drive	Slippery, sharp slopes	-	Coordinates wrong
19/3	Inventory	Restored forest	Tree data + audio data	45 min drive partly difficult	Risky drive	-	Locals friendly
20/3	Inventory	Restored forest	Tree data + audio data	Terrain good, driving difficult	Broken roads	Deer	Passed workers home
21/3	Inventory	Degraded forest	Tree data + audio data	Very sharp slope, broken road	Climbing	Macaque	-
22/3	Could not reach area	-	-	-	-	-	-
25/3	Recorder collection	Plantation (monoculture)	-	-	-	Macaque	Monkeys destroyed recorders
26/3	Travel		Travel to SUAS	Long drive and walk to camp	-	-	-
27/3 - 28/3	Inventory	Pristine forest	Tree data + audio data	Varies by day, generally easy	Divided plots to get rest	-	-
29/3	Travel	-	Returning from SUAS	-	-	-	-
1/4	Recorder collection	-	-	-	Wild cow dangerous, hot day	Wild cow, flying squirrel and gibbon	-
2/4	Inventory + Recorder collection	Degraded forest	Tree data + audio data	Long walk	Elephants in area	Elephant	-

The table summarises the field notes from the observational study, divided by date and category. The studies were conducted in different forest types, from degraded forests to restored and pristine forests. The researcher faced varying terrain and navigational challenges as well as safety risks, such as wildlife and difficult roads. Notes on species and local interactions were also documented, providing an overview of field conditions and observations.

6.2.2 Interview study

In the following section, the results of the interview study will be presented. The interview guide and interview questions can be found in full in Appendix 2. In total, two respondents participated, both working within the organisation but in different divisions.

In the presentation of the results of the interview study, the respondent of the first interview conducted will be referred to as Interviewee 1 and the second as Interviewee 2. In accordance with the interview guide, the results of the interview focusing on organisational and structural factors will be presented, followed by a section focusing on perceptions of biodiversity credits.

Organisation and structure

The interview began by reviewing the responsibilities of the respondents. Interviewee 1 described how the responsibilities involved helping researchers and students to practically carry out their data collection in the management area. The position involves responsibility and planning so that the work runs smoothly. Interviewee 1 describes that he is qualified through his previous experiences and that qualifications such as education and experience are important for the job. Furthermore, Interviewee 1 describes that the tasks are satisfying but that the work is heavy and does not really reflect the salary. However, the respondent underlines that he is proud of the work of the organisation in relation to the mission and his own role in it. He describes that the organisation is important for the local community, for example by contributing to rainforest education in the local school and maintaining a good road network. Furthermore, the local community is important to the organisation as many of the people working in the organisation live there and have everything they could require: a school for the children, a mosque, a church and a grocery store.

Interviewee 1 also describes how the organisation's responsibilities are divided between men and women, with men working mainly in the field and women working in the office. He also describes the safety procedures that are in place, including that lone working never occurs, that it is important to rest occasionally and that there are rest areas around, as well as that when working in the field, a dialogue is held with the local office about where one is and is expected to return.

Interviewee 2 describes that his work includes a large area of responsibility with planning and communication. It is within the respondent's responsibility to ensure that the organisation's mission is implemented in practice, meaning that the restoration mission achieves its objectives. Interviewee 2 states how the position requires specific qualifications, in his case he has a forestry degree and previous experience. Like Interviewee 1, Interviewee 2 also describes being proud of his own role and the organisation's mission, especially as the work contributes to research and education. The work of the organisation is particularly important as the management area is one of the largest in the state.

The structure of the organisation is described as important in relation to the mission and Interviewee 2 says that they have, for example, internal trainee programmes to ensure the competence of the employees where they are aware of tree species, GPS mapping and restoration. They also have a code of conduct within the organisation to promote well-being and a committee that works with safety and health. Interviewee 2 also describes the importance of the organisation to the local community, how a large proportion of people living in the local community work in the organisation and that the organisation has employed around 500 people since its inception. Interviewee 2 also describes the division of labour between men and women where approximately 20% are women.

Perception of biodiversity credits

Interviewee 1 answers simply that he sees biodiversity credits and the associated system as something good that would benefit the organisation. He believes that the system is applicable in the current structure and that it can promote restoration work. He does not see that there are any ethical dilemmas with the system.

Interviewee 2 confirms the positive attitude towards the concept of biodiversity credits. He understands that joining a credit system may require more effort than the current mission but believes it would benefit the organisation especially as they are in need of increased funding. They have qualified employees and the infrastructure needed to expand their mission. Interviewee 2 sees how a biodiversity credit system could benefit both their own and other organisations and sees no ethical dilemmas - He believes that those who invest financial resources in their organisation are ‘at least doing something’ to promote biodiversity and the environment.

7 Analysis

This chapter aims to interpret the collected results to answer the research questions and assess their significance and relevance. The analysis identifies patterns, relationships and implications from the results.

7.1 Species data

The following subsections present a comparison of the mean values of the analysed areas according to the methodology.

7.1.1 Tree data

When the charts and mean values for species richness and species evenness based on the tree data, for each area, were studied it was found that:

The mean species richness for the Pristine area and the Phase 1 area corresponded to the same mean value of 26 species, while the Degraded area had a species richness corresponding to 22 species.

The mean value for species evenness was for Degraded-area higher corresponding to a mean value of 86 individuals than both Phase 1-area corresponding to 74 individuals and Pristine-area corresponding to 65 individuals. The reason for the higher mean number of individuals in the degraded-area was explained by the fact that some species stood out significantly compared to others, where very many individuals of the same tree species were found in one and the same sample plot.

This comparison did not take into account that different numbers of sample plots were included in the different areas, which the mean was based on. Therefore, to control the outcome of the comparison, three randomly selected sample plots were removed from the Pristine-are and Phase-1 area respectively so that the comparison was based on values from 7 sample plots each.

Mean values after corrections:

-Degraded-area (unchanged): S: 22 and N: 86
-Pristine-area: S: 27 and N: 66
-Phase 1-area: S: 26 and N: 74

When the mean values were compared after correction, the outcome was almost the same as before, with the difference that the mean species richness value for the Pristine area was higher than the Phase 1 area:

S, Pristine > Phase 1 > Degraded
N, Degraded > Phase 1 > Pristine

7.1.2 Audio recording

When the charts and mean values for species richness and species evenness based on the audio recording data for each area were studied, it was found that:

The mean value for species richness was for the Pristine area higher corresponding to 39 species than the Phase 1 area corresponding to 37 species, the Degraded area corresponding to 31 species and finally the Plantation area corresponding to 15 species.

The mean value for species evenness was for Phase 1 higher corresponding to 147 individuals than Pristine-area corresponding to 137 individuals, Degraded-area corresponding to 130 individuals and finally Plantation-area corresponding to 87 individuals.

This comparison did not take into account that different numbers of sample plots, where the audio recorders were set up, were included in the different areas, which the mean value was based on. To control the outcome of the comparison, three and five randomly selected sample plots were therefore removed from the Phase 1 area and the Plantation area, respectively, so that the respective area's mean value was based on values from 3 sample plots each.

Mean values after corrections:

-Degraded-area (unchanged): S: 31 and N: 130
-Pristine-area (unchanged): S: 39 and N: 137
-Phase 1-area: S: 37 and N: 168
-Plantation-area: S: 13 and N: 80

When the means were compared after correction, the outcome was the same as before:

S, Pristine > Phase 1 > Degraded > Plantation
N, Phase 1 > Pristine > Degraded > Plantation

7.2 Thematic observation

The following sections present the themes identified through the thematic analysis and in accordance with the methodology.

7.2.1 Observation study

When the observation study in the form of field notes was presented in its entirety in the results chapter, it was categorised for the convenience of the reader, which meant that some obvious themes could already be identified initially. With the thematic analysis, further themes have been identified after both compressing and breaking down the different categories presented in the results section. For each theme identified, the practical significance and impact has also been recognised (Table 4). The observation study and field notes were based on, for the researcher, own experiences.

The themes identified are presented and summarised below:

Table 4. Shows identified themes and their meaning and impact based on the thematic analysis of the observational study

Theme	Description	Practical meaning	Consequence
Task and routines	Staff helps set up sample plots, guides in forest, identifies species, plans tasks, and manages transport.	Experience and field habit	Effective handling of data and sampling
Experience and skills	Field staff excel in tree taxonomy, identification, and terrain navigation.	There is a routine for species identification	Vital for biodiversity-based credit system
Forest type	Degraded (disturbed, undergrowth), pristine (dense, uneven-aged), phase 1 (varied, open), plantation (monoculture, even-aged)	Forest areas vary	Require different measures and may differ in value
Terrain condition	Difficult, no paths, dense, slippery.	Accessibility	Increased risk of accidents
Accessibility	Accessibility is good; close to Luasong, good road network.	Easier logistics and field operations	Facilitates staff mobility and sampling
Risks	Risks: difficult terrain, dangerous animals, heat, no phone coverage.	Requires risk management	Protect staff and conduct safe fieldwork
Safety routines	No solo work, equipment, first aid kits, report fieldwork plans.	Reduces the risk of accidents	Maintain the safety of staff
Missing safety routines	Emergency transmitter, climbing equipment	Increased risk	Accident
Direct species observation	Snake, macaque, gibbon, deer, wild boar, wild cow, red leaf monkey and flying squirrel	Confirms the presence of species	Can increase the biological value
Indirect species observation	Deer, wild boar, sun bear and elephant (tracks)	-II-	-II-
Communication	Language barriers sometimes caused miscommunication	Affects planning	The initial plan can be modified
Social norms	Staff show professional pride, punctual, and organized. Men handle fieldwork; women do admin. Gender norms observed. Everyone is hospitable and helpful	Respect and understand important	Fosters a positive climate of co-operation
Local community	Luasong: school, supermarkets, mosque, church, and the organization's office, is a vital hub. Staff live there, and citizens are proud of the organization	Making life simpler as an employee	Local support is essential to adoption biodiversity projects
Illegal activity	Observed illegal settlements and palm oil cultivation in area	Protected land is utilised	Can affect biodiversity
Navigation	Used GPS, offline maps, compass, and marked trails	Several routines	Ensure data collection
Physical and mental strain	Long forest walks, difficult terrain, hot, humid. Risk of dizziness	Challenging working conditions	Requires good health protection
Environment and climate	Long dry period: nearly empty rivers, extreme heat	Impact vegetation	Requires understanding
Logistics and roads	Good road network, but variable quality; rain causes mud, slipperiness, and collapses	Affects mobility	Can enable and prevent labour
Unpredictable events	GPS failure, incorrect map, broken roads, power outage	Affects planning	Requires flexibility

The thematic analysis of the observation study highlights the critical roles and challenges faced by field staff when sampling in the forest, emphasising the need for risk management, effective logistics and community support. Ensuring staff welfare and effective data collection is crucial for biodiversity conservation, especially in diverse and sometimes challenging environments.

7.2.2 Interview study

Some initial themes could already be identified in the results chapter through the structure of the interview questions. This section presents further themes identified through the thematic analysis based on the respondents' answers. The answers have been compared between the two respondents and in some cases summarised and, in some cases, broken down to identify different themes. The identified themes are also described with practical meaning and impact (Table 5).

The themes identified are presented and summarised below:

Table 5. Shows identified themes and their meaning and impact based on the thematic analysis of the interview study

Theme	Description	Practical meaning	Consequence
Work description and responsibilities	Both respondents' work includes plan and responsibility: one for fieldwork and data collection, the other for overall structuring	It ensures multi-level planning and structure from data collection to strategic planning	Ensuring effective implementation and monitoring
Qualifications and skills	Both roles require experience and training. Interviewee 1 has experience; Interviewee 2 has a forestry degree and sector experience	It ensures both practical experience and theoretical knowledge	Can be expected to handle tasks in the framework of biodiversity credits
Salary	Both agree that the salary is sufficient. Interviewee 1 thinks it is a bit modest but acceptable because of job satisfaction	It affects work commitment	Affects long-term commitment and possibly realisation of credit system
Responsibility of the organisation	Both interviewees believe the organisation works responsibly and aligns with its mission	The organisation follows professional standards	Strengthens trust - can favour credit systems
Professional pride	Both are proud of their contributions and the organisation's work in protecting natural resources	Job and organisational satisfaction	Better performance in implementation of credits system
Community engagement	Both consider the organisation to have a positive impact on society by education, infrastructure and job opportunities	Strengthen the organisation's relations with the community	Facilitate the acceptance of the biodiversity credit system
Gender balance	Both describe the gender balance: 20% women among 58 employees, with men in the field and women in administration or nursery	Affect staff dynamics	Diversity of perspectives in implementation of biodiversity credit system
Code of conduct	Workers follows office attire etiquette and adheres to Sabah Group's standards: "Dynamic, People Oriented, Committed, Caring"	It ensures consistent and professional behaviour	Professional behaviour in relation to credit standards
Safety procedures	Both interviewees mention safety procedures, including first aid kits, location dialogue strategy, and office recovery room. Interviewee 2 notes a committee that handles safety	Ensures a safe and secure working environment	Security procedure in place for future implementations
View on biodiversity credits	Both respondents support biodiversity credits for organisational benefits, noting resources and infrastructure readiness, though additional restoration efforts are needed. Interviewee 2 highlights financial benefits and they do not see any ethical concerns in promoting biological values through investment.	The organisation is ready to integrate biodiversity credits to improve its sustainability performance and financial results	Can contribute to long-term ecological and economic sustainability

The thematic analysis of the interview study shows a solid structure and commitment within the organisation, with an emphasis on integrating both practical and theoretical expertise to

ensure their mission. Key findings include the societal impact, professional pride and the organisation's readiness to embrace biodiversity credits system.

7.3 Analysis in relation to hypothetical credit system

Considering the requirements presented for the hypothetical credit system in the methodology chapter, the following is a review of how the results were analysed in relation to these.

To clarify whether the presented lists of requirements could be complied with consideration of the results, one of these three notes was written next to each requirement: "**Can be complied**", "**Cannot be complied**" or "**Unclear if can be complied**".

Whether a requirement could be met or not was not a matter of interpretation in this section, instead the analysis was based entirely on whether the requirement could be fulfilled based on the information provided in the results section, for example related to organising or measuring species data (complemented with already known facts such as the empirical background of the organisation and project). This meant, for example, that in cases where "unclear if can be complied" was stated, there was not enough information provided.

7.3.1 Analysis requirements for PV Nature Standard

The analysis was based on the requirements presented to achieve the PV Nature Standard. See description of the requirement in the methodology chapter, section 4.4.3.

There are a total of seven overarching requirements that need to be met to achieve the PV Nature Standard. These are summarised in the methodology chapter: Project start time, Project type, Project Coordinator, Land status, Project participants, Land Tenure and User rights and Activities and interventions.

The projects within the framework of the organisation are ongoing and are aimed for restoration and conservation and intend to move from a lower to a higher biodiversity status. The work also excludes land that has been farmed for more than ten years, however, the work was started on partially bare ground due to the forest fire that affected what is now the management area.

Furthermore, the coordinator of the current work is a government agency. The management area and the ongoing work do not affect other activities and benefit the local community, in particular by providing job opportunities and employment to a large proportion of the local population. Furthermore, ongoing work provides for the cultivation of indigenous tree species and offers training to employees and schoolchildren.

This summary means that almost all points can be marked as **“Can be complied”** except for the first point addressing project type: It is unclear how Plan Vivo views the fact that ongoing and future work is taking place where there have been fires in the past - hence this point is marked as **“Unclear if can be complied”**.

7.3.2 Analysis methodology and documentation for certification

The analysis was based on four sets of requirements and steps that needed to be met in order to adopt the methodology for data collection and protocol keeping in the process of achieving certification. See description of each requirement in the methodology chapter (section 4.4.5).

Biodiversity measurement parameters

The parameters of the biodiversity measurement requirements will be reviewed as above, describing how the requirement is met and whether it is deemed to be achievable (Table 6).

Table 6. Shows the biodiversity metric to be fulfilled, how it is followed and whether it can be complied

Parameter	**How the demand is met**	**Compliance status**
Species richness	As the result shows, it is possible to measure species richness and obtain measurable results	Can be complied
Species diversity	Species diversity has not been fully calculated, but both species richness and species evenness, which are both components of species diversity, have been estimated and generated measurable results	Can be complied
Taxonomic dissimilarity	Taxonomic dissimilarity has not been estimated. But, the field staff provided taxonomic information about the identified species which could have been used in such an estimation	Can be complied
Habitat health	Habitat health has not been estimated in full, but notes on biological environments visited during data collection are described differing both at local level and between each other	Unclear if can be complied
Habitat spatial structure	Habitat spatial structure has not been estimated, but notes on biological environments visited during data collection described that some environment types are interrelated	Unclear if can be complied

The summary of the measurement requirements to be met is that three out of five can be complied. The two that cannot be met ("habitat health" and "habitat spatial structure") are both parameters that have not been measured within the scope of the study and hence there is some uncertainty about them.

Steps of the methodology

The sampling design was performed during data collection. It could be completed, but communication difficulties and unpredictable events affected the planning, making it unclear if it can be complied with. The data collection mechanisms provided by the organization worked out in this study and can be complied with. Field staff were able to identify all tree species encountered using a software tool or human expert. For animal species, an external consultancy was used for identification, making it unclear if this can be complied with. No quality review has been carried out within the organization, but there are strong links to research within the organization that could provide expertise, making it unclear if quality control by a human expert can be complied with. The calculation and valuation of metric values can be done by PVF and can be complied with.

This means that of the five steps to be completed, two could be marked as "**can be complied**" ("data collection" and "calculation and valuation of metric values"). The other steps ("sampling design", "identification of species by software tools or human expert" and "quality control by human expert") were marked as "**unclear if can be complied**".

Overarching sections for data

- Species occurrence: Refers to the above - **Can be complied**
- Relative abundance of species: Refers to the above - **Can be complied**
- Extent and type of habitats found within a biological area: Refers to the above - **Unclear if can be complied**
- Local environmental conditions, such as weather and local climate, during the period of data collection: The staff in the organisation can provide that information - **Can be complied**

Collected data requirements

The data collection requirements consist of five parts and will describe how the requirement is met and whether it is deemed to be achievable (Table 7).

Table 7. Shows the data collecting requirement to be fulfilled, how it is followed and whether it can be complied

Parameter	How the demand is met	Compliance status
Cover a sufficient taxonomic range	Within the framework of this study, more than four target groups were investigated	Can be complied
Methods that allow probability calculation	Probability was not estimated, but the information provided from data collection in combination with the organisation's experience of previous data collections should allow probability to be estimated	Can be complied
Large spatial and temporal scale	The organisation's management area offers a large areal and data collection over time (audio recorders) worked out. Maps of the entire management area classified by habitat type are available	Can be complied
Data collection methods should be robust to failure	The same method of collecting tree data and audio recording data was used for a month, which worked, but navigation errors and technical problems affected the method	Unclear if can be complied
Data collected must be fully auditable and of high integrity	All collected data was digitally registered and documented with dates and coordinates	Can be complied

Of the five parameters examined, all but one could be monitored ("data collection methods should be robust to failure"), which was marked as uncertain. This is because, although the data collection methods worked well in practice, they were not hundred percent resistant to, for example, animal damage or navigational problems. It is not clear whether some failures related to external factors may be okay within the framework of a robust method.

7.3.3 Analysis project requirements

The analysis was based on three general requirements that needed to be fulfil for a project to start the process of achieve the PV nature certification. See description of each requirement in the methodology chapter (section 4.4.6).

To summarise, the project requirements is that: 1) The project must restore/conserve land, promote biodiversity and provide climate, socio-economic, and environmental benefits, 2) The project must contribute to socio-economic benefits in the long term and 3) The project cannot be implemented on land that has been degraded intentionally from a biological ecosystem point of view over the last ten years.

To assess the above requirements, it is found that: The project and the organisation's mission relate to restoration/conservation and the promotion for biodiversity. Socio-economic benefits are also identified. Climate and environmental benefits have not been examined. Ongoing projects and their funding are important for the organisation and the surrounding community. No logging or similar has taken place for over ten years.

This implies that the first requirement is assessed as **"Unclear if can be complied"** because no climate and environmental benefits have been examined. But that the other two requirements can be fulfilled **"Can be complied".**

7.3.4 Summary analysis of hypothetical credit system

The majority of all requirements that were listed in the methodology chapter and reproduced in the analysis section could be categorised as **"Can be complied".** Some were listed as **"Unclear if can be complied"** and none were listed as **"Can be complied".** As mentioned, each requirement's categorisation was based on the information that the results chapter could provide as well as some known facts presented in the empirical background.

7.4 Analysis in relation to theory

The theoretical framework described in Chapter 3 has been implemented in the analysis to evaluate the concept of biodiversity credits within the Payment for Ecosystem Services (PES) framework and its interaction with biodiversity. The analysis integrates the theory by examining species data, thematic observations and interviews to assess biodiversity, organisational factors and the practicability of a PES system.

Species richness and evenness were measured across different land areas to provide empirical data on biodiversity, which is important for the evaluation of ecosystem services. The thematic observations highlighted the practical challenges and social conditions affecting PES implementation. Interviews with staff provided insights into organisational readiness and community impact, in line with the PES framework's emphasis on local engagement and financial incentives.

In addition, the analysis aligned the data collection methodology with PES standards (hypothetical credit system), identifying both compliance and elements that needed further clarity. This approach ensured that the theoretical principles were applied to assess the potential for implementing a PES system.

In the following sections, a more detailed description of the links between analysis and theory that could be identified is provided.

7.4.1 Analysis of species data in relation to theory

Relationships between the analysis of the species data and the theory can be found, here some essential ones will be presented. A functioning PES system needs to be able to be assessed through indications of the health of biodiversity, for example by studying species richness and evenness. The analysis shows differences in the different land areas, which could hypothetically be used as a way to evaluate how effective a PES system or biodiversity credit system is. Grima et al. (2016) describe how PES systems that promote the conservation of biological resources are particularly successful, such as a biodiversity credit system - in such a system, it may be particularly important to be able to assess suitability through species richness and evenness. When analysing species richness across the different areas, it was observed that the pristine area had the highest species richness. This is consistent with the theoretical framework of PES, which assumes that conservation management leads to increased biodiversity (Grima et al. 2016). The higher species richness in the pristine area suggests successful conservation efforts, which is an important goal of PES systems.

Another link can be observed. Farley and Costanza (2010) describe how one way to promote pricing of biological values is through mapping and monitoring of biological systems and PES systems. The analysis shows that the method of collecting species data through audio recording worked and that it is also possible to discern differences between the different land areas in terms of species richness and evenness. Sound recording could thus theoretically be a tool that can be used in mapping and monitoring to promote PES systems.

7.4.2 Analysis of thematic data in relation to theory

Links to the theory can also be made in the thematic analysis. Grima et al. (2016) state that an important factor for a successful PES system is the temporal and spatial scale. In the thematic analysis, themes relating to forest types and terrain conditions that describe the spatial distribution of biological values have been identified.

The thematic analysis also highlights identified themes that address the interaction of the local community with the organisation and its mission for the conservation of biological values. Farley and Costanza (2010) describe how effective PES systems involve local actors and the local community. Analysing the local community and local actors also strengthens the link to theory through IPBES (2017), which outlines how PES system target local communities as they are expected to be responsible for the conservation of biological values. The thematic analysis has also identified themes that describe the competence of field staff and its significance for the work, which can also be linked to the importance of local support for a PES system that the theory addresses. Grima et al. (2016) also strengthen the link to the analysis that describes the importance of local support: well-functioning PES systems are expected to favour local livelihoods. The analysis describes how the organisation promotes local livelihoods and how increased financial resources, through a PES system (biodiversity credits) can be expected to affect these.

7.4.3 Analysis of hypothetical credit system in relation to theory

The analysis of the application of the hypothetical credit system also shows the connection between theory and analysis. As previously established, it appears that local involvement is important for a well-functioning PES system, but something that is also important is local actors and minimal intermediaries (Grima et al. 2016). This is in line with the analysis of the

hypothetical credit system where project coordination is expected to be locally anchored and operate at the governmental level or equivalent, which is also the case in the organisation in question.

As the hypothetical credit system being studied is an established system under the framework of a PES system, several of the requirements that are expected to be met mirror the factors that should be present in a successful PES system as presented in the theory section. For example, the hypothetical credit system also confirms the importance of temporal and spatial scales as presented in the theory section. Furthermore, the hypothetical credit system requires quality control of conservation efforts, which is in line with the monitoring and evaluation of systems and methods discussed in the theory section.

The hypothetical credit system focuses a lot on how conservation interventions benefit the local community and local livelihoods, which, as mentioned earlier, emerges as a success factor in the theory.

A further link to both the species data and the hypothetical credit system is the difficulty in valuing biodiversity values: the results show how the biodiversity performance of the organisation interacts with the number of species present in the different land areas, while at the same time demonstrating the difficulties in assessing its importance. There is nothing in the results that assesses the biodiversity performance of the different land areas other than in relation to each other. The difficulty of assessing the biodiversity measures provided by the species data is evident in the analysis of the hypothetical credit system where, for example, the assessment of habitat health appears difficult to evaluate. Thus, if such a circumstance is aggravating in terms of certification, it may lead to an organisation missing out on the financial incentive to promote biodiversity. As the theoretical framework is summarised, there can be some difficulties in applying the empirical results in practice.

8 Discussion

The conclusion chapter uses the three research questions as a structure. The first question will handle the economic, biological and social conditions in the biodiversity concept. The second question will discuss whether the structure of the organisation and the ongoing efforts could be applied in the context of biodiversity credits. The third question will include a discussion about if biodiversity credit can improve biodiversity in rainforest environment. Lastly, sources of errors will be discussed.

The research questions are repeated in full below:

- What economic, biological and social conditions are required to establish the concept of biodiversity credits in the organisation?
- Is the organisation's structure and ongoing reforestation efforts applicable in the context of biodiversity credits?
- Is the concept of biodiversity credits an appropriate way to improve biodiversity in the rainforest environment?

8.1 Conditions for biodiversity credits in the organisation

In order to discuss the first research question, it is divided according to the three conditions to be investigated: economic, biological and social.

8.1.1 Economic conditions

First, it is difficult to get a clear overview of the economic conditions required given the literature review, theory and results. There is no universal system for biodiversity credits and thus no universal system for pricing biodiversity credits. When talking about payment for ecosystem services (PES), which can be described as a more general concept, and which is also a more established concept, there are also no universal systems for pricing. However, it is clear that PES is market-driven, which explains why prices can vary. Furthermore, Grima et al. (2016) maintains in their analysis that part of a successful PES system involves in-kind negotiation, which makes the price picture even more difficult to study. Furthermore, factors such as political systems, natural conditions and policy frameworks in different countries globally can of course be expected to cause considerable variation.

It has also been difficult to get an overview of the scale at which biodiversity credits are sold, which is a factor that may be important in an economic overview. In the Public Purchase conducted by the Swedish bank Swedbank (Swedbank n.d.), it appears that 91 credits were purchased on an area equivalent to 11 hectares. In the costing data presented in the empirical background, regarding the costs of registering projects in the Plan Vivo Foundation (Plan Vivo 2023), calculations were made that included more or less than 50,000 certificates on an area between 500-30,000 hectares. These numbers do not indicate the actual scale at which biodiversity credits are sold, but they do indicate that more than one, up to 8-10 credits can be expected from one hectare.

It also seems clear that a financially established organisation is required to provide the requirements to be included in a biodiversity credit concept, and a PES-system. For example, the Plan Vivo Foundation's system requires that long-term benefits to local communities and the surrounding environment continue even after the project has ended, and that participation in the project should also ideally be locally based (Plan Vivo 2023c). For such a system to

work, it is conceivable that an already established economic infrastructure exists, as in the case of the Yayasan Sabah Forest Group in the community of Luasong.

By studying the known economic conditions of the Yayasan Sabah Forest Group, it appears that the management costs per hectare can be estimated at approximately USD 1500-2500 (Philipson et al. 2020). It is also known that if the organisation were to register a project and apply for certification to sell biodiversity credits, the cost would be approximately £31,850 for a project with an area of 1600 hectares. £31,850 is roughly equivalent to USD 40,493. If the management cost is equivalent to USD 1,500-2,500 per hectare, this implies a total management cost of between USD 2,400,000-4,000,000 for 1,600 hectares, which is a very large cost. In contrast, restoration in the original INIKEA Phase 4 project (which covers the 1600 hectares in question) is expected to last for a period of ten years, which corresponds to management costs of between USD 240 000-400 000 per year. Provided that the organisation can sustain these costs, and that part of the management costs are covered, the organisation should be able to finance a registration and application for certification with the Plan Vivo Foundation.

However, this information is not sufficient to decide on the matter, it only gives an indication of the conditions. The numbers for management costs were based on conditions from 2020 when Philipson et al. (2020) conducted their review, conditions may have changed since then.

In an interview with the head conservation division, it appeared that the organisation is in a situation where they are in need of financial support (Pius Pansang 2024), although the extent of this was not specified. It can be reasoned that if the organisation is able to pay a relatively large sum of approximately USD 40,493 and maintain its operations with associated management costs, any sale of biodiversity credit needs to be able to meet these costs in income.

8.1.2 Biological conditions

In contrast to the economic conditions, it is easier to get an overview of the biological conditions for biodiversity credits. Firstly, the initial conditions are good due to the geographical location of Borneo and Sabah, where according to figures presented by WWF in the empirical background, Borneo holds 6% of global biodiversity (WWF 2024) and the state of Sabah is particularly characterised on the island for its high level of biodiversity.

The Yayasan Sabah Forest Group is responsible for a large area of land, with the INIKEA area alone representing almost 20,000 hectares. The results of the interview study show that the organisation's management mandate is one of the largest in the state of Sabah. This implies that the organisation's management has a large pool of biological resources. In addition, a large pool of *forest holding* of biological resources, which speaks in favour of a valuable holding, as the most valuable biological assets are found in the forest (Pan et al. 2018; Hill et al. 2019).

However, what is difficult in the mapping of the biological conditions is the estimation. It is clear from the literature review how researchers at the highest level disagree on how species should be estimated under the concept of biodiversity (Li & Wiens 2023); it is described that it is challenging to estimate such a broad concept (Purvis & Hector 2000). This is something that has also been reflected in this study as it has been difficult to get a grip on what the estimated values for biodiversity actually mean. When estimating species richness and species evenness, both units of measurement are measurable, and the outcome also reflects what is

expected, where, for example, more species are found where the forest is undisturbed than where it is disturbed - This is also confirmed by the literature review, which shows that human activity, which is what is meant by disturbed, affects the level of biodiversity (Hill et al. 2019). But what is not clear is what constitutes a high value of species richness or species evenness. By imagining what species richness or species evenness looks like in Sweden or other less species-rich parts of the world, it is clear that a species richness of around 30 species within an area of 40x40 metres is comparatively high, but there is nothing in the data to describe how high. With this reasoning, the outcomes from the species data in terms of the level of biodiversity may be good, but not to what extent. In both the outcomes from the tree data and the audio recording data, it appeared that the areas of active restoration (phase 1) and pristine forest showed a higher degree of biodiversity than in disturbed forest, which reflects the expected result and indicates that the biodiversity is measurable and comparable, although the results do not indicate what degree of biodiversity is produced.

The observational study also portrays a diverse environment where differences in the different forest types were apparent and where indirect and direct species observations indicate different types of animal species moving in the area.

When analysing the five biodiversity measurement parameters that should be met according to Plan Vivos standards for certification, it appears that three of the five parameters are considered measurable and two as unclear if they are measurable. The reason why two are estimated to be unclear is because they concern the estimation of habitat, which has not been performed within the framework of this study. However, given the observations of diverse environments noted in the observational study, there should be no problem in estimating habitat conditions. With this reasoning, the parameters can probably be met.

8.1.3 Social conditions

With regard to social conditions, the thematic analysis in particular describes the importance of the organisation and its ongoing restoration project for the employees and the local community of Luasong. Of the approximately 200 people living in the community, 58 people work for the organisation - The organisation can be considered to contribute a high level of employment for the local community. It is also evident that the organisation is contributing practical benefits to the community, such as maintaining roads and contributing to education in the local school. The local population is also visibly proud of the organisation, as evidenced both in interviews with employees and when walking around the local community. The importance of local involvement has been confirmed several times in both theory and analysis (Farley & Costanza 2010; Grima et al. 2016).

The requirements to be met for certification under the Plan Vivo Foundation standards insist that the local community should benefit socio-economically even beyond the scope of the project (Plan Vivo 2023c). If certification can help to improve the financial situation of the organisation to sustain and perhaps even expand its activities, it would benefit the local community with more job opportunities and employment.

8.2 Applicability of the organisation's efforts

To discuss research question 2, the results and the analysis of the requirements for the hypothetical credit system will be reviewed.

The mission of the Conservation & Environmental Management Division is to conserve and promote biological environments and promote biodiversity, which is in line with the Plan Vivo Foundation's agenda and the general description of a PES system's mission. If the efforts made and being made to promote biodiversity are working, an argument can be made for the organisation's eligibility to be part of a biodiversity credit system.

When analysing the species data, it is clear that a higher degree of biodiversity in terms of species richness and species evenness occurs in the pristine and actively restored areas (phase 1) than in the degraded area.

It is above all, the values for species richness that are individually most interesting, as it is considered to say more because species evenness alone does not say as much (Plan Vivo 2023c). For the tree data, pristine showed the highest value for species richness, closely followed by phase 1, and the lowest value was found in degraded. If the pristine area is considered as a kind of reference point of what the level of biodiversity should be without impact or disturbance, the active restoration has worked well in the Phase 1 area as the species richness is almost as high. It is also higher than in the disturbed area, which suggests that the active measures have generated more potential habitats for species. The distribution of the values for species evenness looks slightly different, with the disturbed area showing the highest value, followed by Phase 1 and pristine. In the individual assessment, this does not really mean much, as species evenness needs to be studied together with species richness in order to be valued (which was not done in this analysis). However, it should be mentioned that the higher value can be explained by the fact that the distribution of some individual species was significantly higher than the others, resulting in a skewed mean value. As described in the methodology section, it is not uncommon for the distribution in a disturbed area to consist of a small number of dominant species, resulting in a skewed distribution.

For audio recording data, the pristine area also showed a higher mean value for species richness than for both Phase 1, degraded area and plantation that was included in the audio data. The outcome is similar to the outcome for the tree data where Phase 1 almost reaches the same level as pristine-area, which gives a good indication that the active restoration is working. In the audio recording data, the species richness of the plantation area is also studied, which is interesting from the point of view that the degraded area can also be compared to an expected poorer biological environment, from the perspective of the expected degree of biodiversity. Even though the degraded areas have not been managed to the same scale as the plantation area, their higher degree of species richness shows that a previously managed area left for natural regeneration can recover to some extent. This is again confirmed by the literature review which emphasises that human activity affects biodiversity (Hill et al. 2019).

A further argument in favour of the active restoration actions seeming to work is that the level of biodiversity was found to be high enough not only for the tree data but also for the audio recording data. Perhaps it can be assumed that the number of species will be higher under active restoration because trees are actually planted by selected, native species - which is also the main goal. But for the audio recording data, it is completely out of human control which animal sounds are captured and thus result in a value for species richness.

To summarise the discussion for the species data, the active restoration measures that have been carried out have generated a higher degree of biodiversity than if the active measures had not been carried out.

The analysis for the thematic data is further considered. As regards the capacity of the organisation to integrate a biodiversity credit system into its activities, the conditions seem promising. For example, there is an established habit of planning and carrying out actions within the framework of restoration. Staff are well prepared for the different types of nature and species assessments that may be necessary for the establishment of biodiversity credits, given the experience and/or education requirements and internal training programmes within the organisation. There is also an established infrastructure with local offices, nursery and an established road network throughout the management area. In the interview study, employees maintain that they believe the right conditions exist within the organisation to join a credit system (Pius Pansang 2024).

By studying the analysed requirements for certification according to the Plan Vivo Foundation standards, the outlook also looks promising: none of the requirements reviewed were classified as 'Cannot be complied', but the majority were classified as 'Can be complied' except for a few that were classified as 'Unclear if can be complied'. In most of the cases where the requirements were categorised as 'Unclear if can be complied', it was because the outputs from the results did not provide sufficient information rather than whether there was actual doubt. The analysis of the requirements suggests that registration of projects under the Plan Vivo Foundation framework would be possible.

8.3 Suitability of biodiversity credits in rainforest environment

The third research question is framed from a broader perspective than the previous two. There are elements in the literature review and empirical results that need to be reviewed to discuss research question 3.

In particular, the results from the species data support the idea that a biodiversity credit system can promote biodiversity in rainforest environments. This is because the result 1) demonstrated that active restoration measures lead to increased biodiversity and 2) the biodiversity metrics that were studied and produced the result (species richness and species evenness) are included in the estimation of biodiversity in a credit system.

Based on the thematic analysis, it appears that staff within the organisation believe that ongoing restoration would work in a biodiversity credit system based on the given conditions, including the biological environment. The observation study also revealed that it is practically possible to carry out measurements and surveys in the rainforest environment within the framework of a credit system aimed at promoting biodiversity.

In addition, as described above, Malaysia and Borneo have a so called 'mega diversity' with unique biological conditions (FAO 2020a). It could be reasoned that biodiversity credits sold in Borneo and originating from rainforest environments could be particularly in demand and affect the pricing. A higher price would thus allow more efforts to be made to promote biodiversity, at least within the framework of a serious certification system. It is clear from the literature review that the market for nature credits, and in particular biodiversity credits, is growing in demand (Nature Markets 2022).

There is also a risk in an emerging market for biodiversity and other nature credits, where money is always expected to be the main driver. In a market involving natural resources, the financial figures represent the quick results and the biological resources the long-term results

- This further emphasises the importance of a serious certification system. For a biodiversity credit system to work, the long-term results must also be prioritised. These factors are particularly important to consider in light of the literature review - looking back, one can learn from the carbon credit market that fair outcome is important (Biodiversity Credit Alliance 2024). The risk of "green washing" where inaccurate information about conservation efforts is presented should of course be avoided in the selection of credit system (United Nations n.d.).

Overall, the discussion highlights that biodiversity credits could promote biodiversity in rainforest environments, even if it is not possible to determine it on these bases.

8.4 Discussion previous studies

When previous studies and the literature review are studied, it becomes apparent that several previously known factors can be confirmed in this study. Among other things, the difficulty in valuing biodiversity as Purvis and Hector (2000) stated is confirmed: It appears, as the discussion states, that biodiversity is measurable based on the framework of this study but that it is difficult to assess what the measured values actually mean in practice.

Further, the literature review speaks in favour of how human activity affects biodiversity (Hill et al. 2019). This is confirmed by the results of this study, which show that the land areas with the highest biodiversity are those where the forest has been left untouched or where active restoration measures have been carried out.

The literature review also describes the concept of biodiversity credit as a nascent but emerging concept in the thriving nature credit market (Nature Markets 2022), which is evident in this study: for example, it shows that over 450 organisations are active in the nature credit market, while the concept of biodiversity credit is relatively unfounded.

Lastly, the literature review highlights the importance of including local people in the biodiversity credit concept for an equitable outcome, which is also evident in the hypothetical biodiversity credit system. This factor is confirmed in the results where the presence of the organisation in the local community is of significant importance.

8.5 Sources of errors

A number of sources of error have been identified. First of all, the planning and preparation for the study and the trip were difficult to predict, which led to the study taking shape as the data emerged, resulting in a lot of reworking at the final stage of the study. This made it challenging to maintain a structured planning process.

Further, unexpected events such as animals destroying audio recorders, inaccessible areas and timeframes that did not follow the planning caused the number of planned sample plots not to be realised. This led to an uneven number of sample plots, which affected the averages of the species data and thus the analysis of the results, although adjustments were made accordingly.

Another source of error was the difficulty in verifying economic facts, which affected the examination of the economic conditions. In addition, finding interviewees was more challenging than expected. The search for interviewees did not start until the fieldwork in Borneo took place; if requests for interviews had been sent out earlier, the number of

participants could have been higher. Although only two respondents were interviewed, which is certainly better than none, the results of the interview study would have been more reliable with more participants.

The results from the audio recorders came back much later than expected, which affected the analysis of the species data. With more time available, a more sophisticated analysis of the species data could have been carried out in an attempt to measure biodiversity.

Biodiversity credits are a major and unexplored topic that leaves room for many open questions. To facilitate the implementation of this study, further delimitation would have been desirable, perhaps by focusing on only one type of data collection and adapting the study design accordingly.

9 Conclusions

The last chapter of this study aims to present the findings and how they relate to the preceding discussion and the study's research questions in order to finally present the conclusions.

9.1 Summarising conclusions

When the discussion is studied, it becomes clear that all three research questions can be argued about, although no clear conclusions in line with the qualitative work can be drawn.

Below is a repetition of the study's research questions in order to summarise them again in a more general form:

-What economic, biological and social conditions are required to establish the concept of biodiversity credits in the organisation?
- Is the organisation's structure and ongoing reforestation efforts applicable in the context of biodiversity credits?
- Is the concept of biodiversity credits an appropriate way to improve biodiversity in the rainforest environment?

9.1.1 Conditions for biodiversity credits in the organisation

The discussion of the first research question gives the overall impression that there are economic, biological and social conditions for biodiversity credits. For the economic conditions, a more thorough review of current costs is needed, but provided that the current management costs are correct and can be maintained, the organisation should be able to finance registration in a credit system. For the ecological conditions, it seems clear that the organisation has the right conditions, especially with regard to the measurable results. However, there is a difficulty in estimating the degree of biodiversity, which needs to be specified. For the social conditions, the organisation's starting point is very good as the organisation already contributes strongly to the surrounding community and is expected to be able to do so to a greater extent with additional financial income from credit sales.

9.1.2 Applicability of the organisation's efforts

For the second research question, the overall assessment is that the organisation's structure and ongoing reforestation projects can be applied in a biodiversity credit system, partly because the results from the species data show that previous targeted restoration efforts have worked and can be expected to do so in the future, and that the organisation has a well-established infrastructure to carry out the mission that follows a credit system. In addition, the organisation appears to be able to meet the requirements for certification under the hypothetical credit system standards.

9.1.3 Suitability of biodiversity credits in rainforest environment

The discussion of the last research question appears more indeterminate, given the broader perspective considered in relation to the previous two research questions. Still, the overall impression is that the concept of biodiversity credits can promote biodiversity in rainforest environments, supported by the results of the species data and the geographical location of the forest area.

9.1.4 Conclusions

In conclusion, the overall assessment of the discussion shows that 1) the research questions can be answered, 2) Yayasan Sabah Forest Group has the potential to join a biodiversity credit system, and 3) a biodiversity credit system is expected to promote biodiversity.

9.2 Suggestion further research

This study focuses on the conditions for biodiversity credits within a specific organisation, which moreover already has an established mission in the promotion of biodiversity. The topic of biodiversity credit is relatively unexplored, large and complex, as shown in this study. Further studies are needed to really investigate the functioning of this concept. It would be interesting to study the phenomenon in future studies from the perspective of an organisation that does not have the same experience of restoration, does the concept work for other types of organisations involved in forest management? It would also be of interest to study in more detail how the 'middlemen' work, meaning those who certify the credits before they can be sold. A more in-depth analysis of how the pricing of biodiversity credits works would have been valuable. Other suggestions for further studies are collaboration between the private and public sectors in the establishment of biodiversity credits, a comparative study between the carbon and biodiversity credit markets, and the integration of biodiversity credits into policy and legislation. The list could go on and on, biodiversity credit is clearly an exciting topic with a lot of ground to cover.

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Appendices

Appendix 1: Case Study Protocol

Activity	Case study protocol
Case study	The concept of biodiversity in Yayasan Sabah Forest Group.
Background	Presented in Chapter 4.
Research question	Presented in Chapter 1.
Previous studies	Presented in Chapter 2.
Design	Presented in Chapter 4.
Case selection	Presented in Chapter 4.
Case study procedures	Presented in Chapter 4.
Case study preparation	Presented in Chapter 4.
Data collection procedure	Presented in Chapter 4. Four types of data were collected: -Tree data through sample plots -Audio recording data – animal sounds -Observation study – Field notes -Interview study – oral with employees within the organisation
Analysis	Presented in Chapter 7.
Ethical considerations	Presented in Chapter 4.
Plan validity	Presented in Chapter 4.
Limitations	Presented in Chapter 8.
Reporting	Presented in Chapter 6 – observations + Presented in Chapter 7 – analysis hypothetical credit system

Appendix 2: Interview questions

Interview questions – Interview no. 1

Biodiversity credits in Yayasan Sabah's Forest Management Area

Name: Albert Lojingi
Position: Field staff

Instructions for interview: The questions are based on the purpose and research questions of the study and the theoretical background of the topic of biodiversity credits. The conversation will be recorded, and the audio file will then be transcribed by an AI-generated transcriber. It is possible to respond in both English and Malay, and the transcription tool is capable of transcribing multiple languages, including Malay. In order for the transcription tool to properly capture the conversation, it is important to speak clearly. If the question is answered in Malaysian, please start your answer by saying which question you are answering as the interviewer (Clara) will be able to follow the conversation more easily when the transcripts are translated into English.

Participation in the interview is completely voluntary and can be cancelled at any time, even after the interview has been conducted. It is okay to be anonymous in the study. It is also okay to add, change, or delete something in the answers after the interview has been conducted. It is possible to read through the transcript after the interview for potential changes.

Biodiversity credit: One financial compensation system for biodiversity is the concept of biodiversity credits, also known as bio credits or conservation credits. Biodiversity credits are a financial mechanism aimed at promoting the conservation and restoration of biodiversity. This mechanism is like the carbon credit system, where companies or organisations can buy or sell credits based on their impact on biodiversity. The credit should describe how and where an action has been taken, what methods have been used and who has carried out the action. A credit is designed according to a juridical framework and must be certified according to a specific standard, after which the credit can be declared and then traded.

Example:

-Seller: Yayasan Sabah's Forest Management Area,
-Buyer: Other organisation or company in the same area that wants to compensate for its environmental impact, e.g. palm oil producer.
-Actions: Should promote biodiversity, can be leaving the forest untouched as in the pristine areas or treatments that have been carried out in INIKEA, such as gap planting of native tree species.
-Certification depends on the type of biodiversity credit method (there are different ones), but a third party familiar with the certification standards should be the one to assess whether a credit can be issued.
-The price of the credit is based on salaries, resources required for action, rate of biodiversity expected supply and demand.

1. Can you tell us about your work in Yayasan Sabah's Forest Management Area (conservation & environmental management division)?

a) What does your role involve?
b) What are your responsibilities?
c) What does a typical working week look like for you, what are your duties?

2. What qualifications are important for doing your job (education, previous work experience, skills?)?

3. Do you think you get a fair salary in relation to your tasks and responsibilities?

4. Do you think that your organisation is doing a responsible job based on its mission (reforestation, conservation of natural resources)?

5. Are you proud of the work your organisation does?

6. How is the surrounding community (Luasong Village) affected by your activities, both positively and negatively (e.g. school students, employment opportunities for villagers, access to the forest)?

7. What is the division of duties between men and women in your organisation?

8. What are the safety procedures/standards for working in the field?

9. Based on what you know about biodiversity credits, what do you think about the concept as a whole?

a) Do you think that your organisation would have the resources (financial conditions, human resources, biological resources) to carry out more conservation actions if it was required within the framework of biodiversity credits?
b) Do you think it is a concept that could work in your organisation?
c) Do you see any ethical disadvantages in joining a concept such as biodiversity credits (e.g. an organisation that produces palm oil, for example, can present itself as "environmentally friendly" for investing in your business)?
d) Do you think a concept like biodiversity credits can promote biodiversity, both in your organisation and in other organisations?
e) Can the biodiversity credits promote your organisation?

Interview questions - Interview no. 2

Biodiversity credits in Yayasan Sabah’s Forest Management Area

Name: Pius Pansang
Position: Senior Officer

Instructions for interview: The questions are based on the purpose and research questions of the study and the theoretical background of the topic of biodiversity credits. The conversation will be recorded, and the audio file will then be transcribed by an AI-generated transcriber. It is possible to respond in both English and Malay, and the transcription tool is capable of transcribing multiple languages, including Malay. In order for the transcription tool to properly capture the conversation, it is important to speak clearly. If the question is answered in Malaysian, please start your answer by saying which question you are answering as the interviewer (Clara) will be able to follow the conversation more easily when the transcripts are translated into English.

Participation in the interview is completely voluntary and can be cancelled at any time, even after the interview has been conducted. It is okay to be anonymous in the study. It is also okay to add, change, or delete something in the answers after the interview has been conducted. It is possible to read through the transcript after the interview for potential changes.

Biodiversity credit: One financial compensation system for biodiversity is the concept of biodiversity credits, also known as bio credits or conservation credits. Biodiversity credits are a financial mechanism aimed at promoting the conservation and restoration of biodiversity. This mechanism is like the carbon credit system, where companies or organisations can buy or sell credits based on their impact on biodiversity. The credit should describe how and where an action has been taken, what methods have been used and who has carried out the action. A credit is designed according to a juridical framework and must be certified according to a specific standard, after which the credit can be declared and then traded.

Example:

-Seller: Yayasan Sabah's Forest Management Area,
-Buyer: Other organisation or company in the same area that wants to compensate for its environmental impact, e.g. palm oil producer.
-Actions: Should promote biodiversity, can be leaving the forest untouched as in the pristine areas or treatments that have been carried out in INIKEA, such as gap planting of native tree species.
-Certification depends on the type of biodiversity credit method (there are different ones), but a third party familiar with the certification standards should be the one to assess whether a credit can be issued.
-The price of the credit is based on salaries, resources required for action, rate of biodiversity expected supply and demand.

1. Can you tell us about your work in Yayasan Sabah's Forest Management Area?

a) What does your role involve?
b) What are your responsibilities?
c) What does a typical working week look like for you, what are your duties?

2. What qualifications are important for doing your job (education, previous work experience, skills?)?

3. Do you think you get a fair salary in relation to your tasks and responsibilities?

4. Do you think that your organisation is doing a responsible job based on its mission (reforestation, conservation of natural resources)?

5. Are you proud of the work your organisation does?

6. How do you ensure that those working under you are doing a good job according to the standards of the organisation?

7. Do you have a vision or values in your organisation (e.g. code of conduct)?

8. How is the surrounding community (Luasong Village) affected by your activities, both positively and negatively (e.g. school students, employment opportunities for villagers, access to the forest)?

9. What is the division of duties between men and women in your organisation?

10. What are the safety procedures/standards for working in the field?

11. Based on what you know about biodiversity credits, what do you think about the concept as a whole?

a) Do you think that your organisation would have the resources (financial conditions, human resources, biological resources) to carry out more conservation actions if it was required within the framework of biodiversity credits?
b) Do you think it is a concept that could work in your organisation?
c) Do you see any ethical disadvantages in joining a concept such as biodiversity credits (e.g. an organisation that produces palm oil, for example, can present itself as "environmentally friendly" for investing in your business)?
d) Do you think a concept like biodiversity credits can promote biodiversity, both in your organisation and in other organisations?
e) Can the biodiversity credits promote your organisation?

Appendix 3: The observation study and field notes in full

Written reflections from field notes:

-8/3: The field staff have incredible knowledge of the environment and the trees/plants that grow there. it would have been very difficult and time-consuming to try to navigate and identify species without them.

-11/3: There are a lot of people involved in all the tasks, for example when we were putting up the audio recorders in the plantation, there were three field staff from "our team" and another three from Sabah Softwood Berhad - which was not needed for the task.

-12/3: Wondering why there is not more safety equipment, I have not seen any emergency transmitter for example (since we do not have network connection in the forest and are far from the road it can be good in difficult terrain), also no first aid kit taken out to the forest.

-15/3: Among staff, it seems common to drive very fast on the forest roads, in some cars the safety belt is broken, and the roads are not of the best condition - safety risk

-19/3: This day was tough. There is a big difference to do one plot area like previous and 4 like today. The heat, the difficult terrain with extremely sharp parts and heavy backpack made the day challenging. We got home at eight in the evening.

-21/3: Very good community unity in Luasong and surrounding area. Despite different cultures and religions, everyone gets along together so good. For example, Ramadan and Easter are both coming up, everyone has great respect for each other's celebrations.

-22/3: The areas under the organisation's management are very large and there are parts where nobody has been for a very long time. Today, a situation arose where we could not enter the intended area due to a large river and difficult terrain. The river was not visible on the map and the field staff did not know what the area looked like. We had to skip this area and apply for permission to go through from the other side over Sabah Softwood Berhard's land.

-Between 21/3-25/3 electricity was out in the whole village of Luasong (powered by diesel generator for the whole village) so it was difficult to work from the computer, of course hot without fans also. We were able to charge our phones at the local restaurant which had its own generator luckily, the staff there are very helpful.

-Between 26/3-29/3: We needed to stay in SUAS for three nights to complete the inventory there as it was too far away to travel back and forth. We lived very primitively. the campsite was a pavilion (roof without walls) where hammocks were put up to sleep. We had no running water, electricity, or internet connection. We brought a gas stove for cooking and our own drinkable water. Had to shower and wash dishes in the nearby river. Very cold at night as we forgot duvets. A thrilling experience.

- Everyday: The heat is a big part of working in this part of the world in general. We tried to be out as early as possible every day, leaving around 7am to get as much work done as

possible before it got too hot. The field workers usually start even earlier. Some days were hotter than others, and there was a big difference in how challenging it was with only a few degrees difference - this was not only the case for us students, but also for the fieldworkers who are more used to the heat. The time of our work was also characterised by a long period of drought.

Other experiences:

-9/3 visiting nursery in Luasong: we visited the organisation's own nursery that supplies all reforestation with planting material. The seedlings are derived from seeds of indigenous trees found within the organisation's own forest holdings. It was great to see that they have a circular cycle of materials. It was clear that the ongoing drought had affected several of the seedlings.

-31/3 About the interview experience: It was difficult to find people to interview, which is probably related to language barriers and the fact that many are unfamiliar with the topic of biodiversity credits - people did not feel comfortable enough. The aim was also to include some of the female employees as well as employees from different departments of the organisation than the two who finally participated. However, in the two interviews that were conducted, I felt that it was very important for the respondents to be able to offer the interview questions and information in English and Malay, and to have the option of answering in both English and Malay - I felt that they became more comfortable. I found that both interviewees became more interested in biodiversity credits as the interview and conversation progressed.

	8/3	11/3	12/3	13/3	14/3	15/3	18/3	19/3	20/3
Activity	Inventory degraded forest	Putting up recorders in plantation	Inventory Pristine forest	Inventory degraded forest	Inventory Pristine forest	Inventory degraded forest	Inventory Pristine forest	Inventory Phase 1 INIKEA	Inventory Phase 1 INIKEA
Site	P1	PL1-PL8 (Sabaha softwood Berhad)	P2	P3	P4	P5	P6	KE27O KE5O KE29	KE2, P7, P8
Task	Sample plot and measurement of trees	Putting up 8 audio recorders in 8 different stands with different age of eucalyptus plantation	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder
Routines/ methods	The field staff helped with measurements and identified the tree species, very depending on their knowledge. They look at leaves on the tree and the ground, on the bark and on the wood	The staff of Sabah softwood Berhad followed us to the different stands. Recorders were put up in trees with steal wire	Assisted by staff in identifying and measuring the sample surfaces	-II-	-II-	-II-	-II-	-II-	-II-
Forest/stand	Undergrowth	Plantation, monoculture, and very fast-growing ground vegetation	Difference between pristine forest and disturbed forest. More vegetation, more species of trees, etc in pristine.	Clearly disturbed with lots of undergrowth	Very dense with trees of different ages, many younger trees/plants. Almost no ground vegetation, only decaying leavesv	Vegetation very disturbed, a lot of vegetation in gaps. A lot of dead wood, standing and lying	-	Line planting of trees (native species)	Varying between different sites, generally more open areas - line planting.
Terrain/accessibility	Difficult terrain, no real paths, need to "cut down" vegetation to get through	-	We had to walk almost 2 km one way in the forest to get to the site - it was tough in dense vegetation. It was muddy/slippery and	Easier terrain than before. Shorter distance to the site, about 300 metres	1,5 h walk to the surface, we followed the river. Very sharp slopes in some parts - we had to climb	A short walk about 200 metres to site. The site ended up straight in a slope due to randomisation.	Only a few hundred metres walk. But in parts very sharp slopes, due to rain at the weekend very slippery and muddy	Lots of walking in the forest. 4 plots at 4 sites had to be made. Very difficult terrain in parts, sharp slopes	Lots of walking today too but terrain okay, could walk a lot on

			very sharp slopes in some parts					and "cliffs", hilly terrain. Slippery, muddy difficult to get a good grip.	old forest roads whic h made it easie r.
Navigation	GPS	Maps, field staff	GPS, also staff made markings to help us find our way back	-II-	-II- + river	GPS broken, google maps offline map instead	-II-	-II-	-II-
Safety routines	Protection for leeches, first aid kit in car, never alone, “rubber shoes” for good grip	-II-	-II-	-II-	-II-	-II-	-II-	-II-	-II-
Risks	Snake	Roads	Snake, sharp slopes	-	Difficult to climb and rocks/mate rials fell. leeches got stuck in clothes	Sharp slopes	Easy to slip in slopes due to rain	Easy to slip in slopes and sharp slopes Became dizzy from the effort and heat. A leech also got stuck on my back - risk of infection	Driving to area were risky due to poor road condition and rain
Accessibility roads/transp ort	First car, then walk	Good road network around the area, but some roads in poor condition, broken and overgrow n	In this part of the area, the road network was good. But the quality of the roads varies	About half an hour's drive from Luasong	Site in Luasong next to river	About half an hour's drive from Luasong	About half an hour's drive from Luasong	About 45 min drive from Luasong, bad condition s of roads partly in INIKEA-area	About 2 h drive to get to the area, then another 500 metres walk before arriving to forest due to broken road. It had rained the night before which resulted in the car roads being extremel y slippery and the roads were broken/to rn down

Species observations	Snake	Tracks of wild boar and elephant, saw macaque (monkey), red leaf monkey	Tracks of deer and sun bear. Saw different bird species, snake and wild boar	Tracks of wild boar and elephant	Tracks of wild boar and sun bear, saw macaque	Tracks of deer	-	-	Saw a big deer
Cultural experiences	Communication problems with staff due to language barrier	Male staff only shook hands with the men in our team when we arrived/where leaving	Staff are very conscientious	-	-	-	Communication with staff becomes difficult at times, - affects the planning of work - changes at last minute	-	-
Surrounding community	-	Strong sense of professional pride	You meet many people working in the organisation when out driving on the roads in the area	The forestry organisation has a strong connection to the village of Luasong. many are proud and wear the organisation's logo on their clothes even in private	-	-	Everyone (staff and community) is very hospitable and friendly. Offer local food, help with things and are curious about our job	-	Drove past the workhouses where the fieldworkers live. Small camping cabins with all the necessities, some coming from other parts of the country to work in the organisation
Other	We noticed that people were living illegally along the forest edge and were growing palm trees	Heavy security in the area, several checkpoints	-	-	-	-	-	Coordinate google maps showed wrong, about 500 m in wrong direction (much in difficult terrain), lost much time	-

	21/3	**22/3**	**25/3**	**26/3**	**27/3**	**28/3**	**29/3**	**1/4**	**2/4**
Activity	Inventory degraded forest	Were supposed to do plots in degraded corridors, INIKEA but due to no access	Picked down audio recorders in Sabah Softwood Berhard	Travelling to SUAS	Inventory Pristine forest	Inventory Pristine forest	Went home from SUAS	Picking down audio recorders	Inventory degraded forest + picking down recorders

		we could not enter							
Site	P9, P10	-	-	Putting up camp	SUAS19 SUAS14	SUAS4 SUAS9	-	-	P11, P12, P13
Task	Sample plot and measurement of trees + putting up audio recorder	-	-	-	Sample plot and measurement of trees + putting up audio recorder	Sample plot and measurement of trees + putting up audio recorder	-	-	Sample plot and measurement of trees
Routines/ methods	-II-	-	-	A handful of staff came along to help us carry all the stuff to the	40x40 plots in already existing 100x100 plot	40x40 plots in already existing 100x100 plot	-	-	Assisted by staff in identifying and measuring the sample surfaces
Forest/stand	-	-	-	-	More open, uneven-aged but less dense, not as much fast-growing species as lianas, dead wood in the gaps	More dense, smaller trees in gaps	-	-	-
Terrain/accessibility	Long distance between plots. New record in sharp slopes, we had to do actual climbing	-	-	Half hour of walk to the campsite. there was a "path" and we had to cross a river. Heavy to carry packing.	Easy terrain, not to dense and no slopes, but long walk	Easy walking but a very long up hill to get to plot	-	-	Long day – much walking, but okey terrain
Navigation	-II-	-	-	-	GPS, compass	-II-	-	-	Google maps offline map
Safety routines	-II-	-	-	-	-II-, divided plots over two days to get rest	-II-	-	-	Protection for leeches, first aid kit in car, never alone, “rubber shoes” for good grip
Risks	Sharp slopes and climbing	-	-	-	-	-	-	Wild cows ran out of bushes - Can be dangerous Also,	Elephants in the surrounding area

								very hot this day	
Accessibility roads/transport	About 40 min drive to area. Road broken so needed to walk past part to get to site	-	-	Long drive to SUAS about 2 h	Walking straight from camp	Walking straight from camp	-	-	About one hour drive
Species observations	Saw macaque	-	Saw macaque	-	-	-	-	Saw wild cow, flying squirrel and a gibbon	Tracks of elephant
Cultural experiences	-	-	-	-	-	-	-	-	-
Surrounding community	-	-	-	-	-	-	-	-	-
Other	-	-	Probably monkeys had destroyed/picked down 2 out of 8 audio recorders collected in the plantation.	-	-	-	-	-	-

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